Introduction

Inland Waterways
Opening the Channels

This issue of *TR News* highlights the role of inland waterways in the growth and development of the nation's economy. The lead article traces the development of the Erie Canal, observing that just about everything a person needs to know about transportation—particularly planning, but also financing strategies and practical education—can be learned through insights from the canal's rich history.

Readers also will glimpse how Europe is rediscovering its historic waterways to accommodate the anticipated increase in cargo shipments within the eastward-expanding European Union (EU). National and international initiatives are integrating inland navigation into the EU transportation network, and the Rhine-Main-Danube Waterway, which links to ports on the North Sea and the Black Sea, is a major focus. Europe increasingly views waterways as an environmentally friendly means of providing low-cost transportation for cargo and of relieving roadway congestion.

Two other articles examine economic measurements that are key to waterway system development and maintenance policy in the United States. One offers a perspective on allocating federal funds to maintain the inland waterways' aging infrastructure. The other provides an overview of a model developed by the Tennessee Valley Authority for estimating river efficiencies and fuel tax collections, with insights gained from applications to data from the Ohio and Lower Mississippi Rivers and their tributaries.

Other features in this theme issue report on safety efforts that have contributed to the downward trend in waterway incidents and on more effective, high-tech ways to integrate inland waterways into the intermodal transportation system. A Point of View article illustrates the transportation system's vital need for the redundancy of water freight routes. Channels also are opened to other waterways topics in brief articles on bringing the ocean to Oklahoma and on a collision test in Florida that will affect future bridge design specifications—a subject of immediate interest with the recent collapse of an I-40 bridge in Oklahoma after a river tow crashed into a support pier.

The TRB Committee on Inland Water Transportation has assembled an interesting, informative, and comprehensive collection of articles on inland waterway transportation, offering historical, international, and domestic perspectives.

Robert W. Portiss

Robert W. Portiss
Port Director, Tulsa Port of Catoosa, Oklahoma
Chair, TRB Committee on Inland Water Transportation

EDITOR'S NOTE: Appreciation is expressed to Joedy Cambridge, Marine and Intermodal Specialist, TRB, for her efforts in coordinating this issue of *TR News*.

Just About Everything You Need To Know About Transportation You Can Learn on the Erie Canal

CATHERINE T. LAWSON

The author is Assistant Professor, Geography and Planning, and Interim Director of the Masters in Urban and Regional Planning Program, University at Albany, New York.

Built with shovels and strong backs, New York's Erie Canal, connecting Buffalo on Lake Erie with Albany on the Hudson River, brought new dimensions to the planning and building of inland waterways, as well as new appreciation of the associated benefits of accessibility and mobility. The implementation of the Erie Canal plan was remarkable because the state received no financial assistance from the federal government.

The canal not only provided connections to expand westward but also promoted economic activities, improved mobility for goods, and opened new opportunities for passenger travel. The history of the canal offers unique lessons for transportation planning on the role of education, the use of financ-

Congestion caused problems on Erie Canal from the beginning, with most backups occurring near locks. Low water level, perhaps caused by break in canal wall, added to this tie-up (circa 1900).

ing strategies, the impact on economic activities, and the opportunities to serve passengers.

Brief History

In its original form, the Erie Canal was a trench 40 feet wide, 4 feet deep, and 363 miles long, connecting the Hudson River at the east with Lake Erie in the west. The difference in elevation between the two endpoints was nearly 600 feet. When the project was planned, the technology for building a system of locks—including the necessary five-tiered set of double locks at Lockport near Buffalo—had yet to be developed (*1*).

Construction began in 1817. State legislation established the Canal Fund, to be administered by elected officials. Sources of revenue included

◆ A state loan, to be repaid with tolls collected from canal users;

◆ The sale of land donated to the state by speculators hoping to profit from the increased values of adjacent property after the canal's construction;

◆ A levy on items sold at auctions;

◆ Lotteries;

◆ Taxes on properties within 25 miles of the canal;

◆ A tax on salt; and

◆ A tax on Hudson River steamboat travel, which was expected to increase with the opening of the canal (2).

PHOTO COURTESY OF ERIE CANAL MUSEUM, SYRACUSE, NEW YORK.

Even before the canal was completed, portions were put to use by farmers, merchants, and passengers making both short and long trips. The boats were pulled by mules led by men or boys walking at a steady pace along towpaths above the canal. Completed in 1825, the canal was so successful that it immediately became congested, overwhelming even the strongest early critics of the project. The Erie Canal experience offers insights into many aspects of transportation planning.

Building Infrastructure

Long-Range Planning

The vision of the construction of a single facility to connect Lake Erie with the Hudson River and beyond is an early example of long-range planning in the United States. The concept also took advantage of a phasing strategy—the project did not begin at one destination point and move progressively to the other.

The first segment to be built was east of the midpoint, near Rome, New York, where the soil was easy to dig and the ground was level. Subsequent phases required a variety of strategies—for example, in the swampy areas of the route, workers had to wait until a winter freeze killed off malaria-carrying mosquitoes (3).

The planning of the infrastructure was distinguished by a willingness to begin without detailed plans for the remaining sections. Most notably, 83 locks were needed to raise and lower boats from 2 to 15 feet. The "deep cut" along three miles at Lockport was accomplished during the last phase of canal construction, applying the latest technological advances in blasting and rock removal (2).

As in modern long-range planning, the engineering was not complete when the original resources were committed to the project. Many challenges were yet unsolved, any one of which could have prevented the completion of the project and the full functioning of the water connection.

Work Force and Training

Photo courtesy of Erie Canal Museum, Syracuse, New York.

Mule driver or hoggee with mule team pulling barges and other vessels along canal (circa 1900). Mules were favored because they were sure-footed, did not overeat, and refused to drink polluted water.

Canal boats approaching lock near Mohawk River, adjacent to canal at left. To stop boats pulled by animals, boatman attached short rope to bow, jumped ashore, wrapped rope to post or cleat located every 25 feet, and then moved from post to post, slowing boat—a process known as "snubbing."

Specialized Skills

The first canal segment, near Rome, fronted on lands owned by farmers, who became the project's first construction work force. The farmers also contributed a knowledge of local soils—for example, they knew that it would be easier to dig after the land was plowed. The farmers also had expertise in tree stump removal, leading to the invention of a large wheel with pulleys to cinch up and extract stumps—seven men and a team of oxen could remove up to 40 stumps per day (4).

Hired laborers—often single male immigrants from Ireland—built the remainder of the canal. The new work force developed specialized knowledge and skills using simple technology.

Small contractors, not the government, hired the majority of the workers (2). This pushed the risk of increasing construction costs—or the potential for profit by increasing productivity while reducing costs—onto the contractor with the lowest bid. Immigrants provided a stream of inexpensive labor, and the Erie Canal project provided employment for a large group of men eager to leave Ireland and Wales for work.

Photo courtesy of Erie Canal Museum, Syracuse, New York.

College of Civil Engineering

The challenges of moving the earth, building the canal structures, and solving technical problems brought to the forefront the need for formal education in civil engineering. When the canal project began in 1817, there was no adequate engineering training in the United States. The canal itself became a school of engineering (4).

The training was shouldered by a group of men from a variety of backgrounds. James Geddes, John Jervis, Nathan Roberts, Canvass White, and Benjamin Wright were among the original canal builders who recognized the need to establish an institution to provide the technical training for infrastructure projects (2).

In 1824, Stephen Van Rensselaer, a member and president of the canal commission, founded the Rensselaer School, later renamed Rensselaer Polytechnic Institute (RPI), in Troy, New York, the first civil engineering school in the United States (5). Named head of the faculty was Amos Eaton, a geologist who had participated in solving canal project challenges.

Eaton wanted to provide a popular and practical technical education (5). His innovative theories and methods aimed at instructing students in the application of science to common activities (6). Eaton later established a "traveling school of science," taking RPI students on educational adventures on the Erie Canal (6). Most of the engineers who worked to complete the canal were RPI graduates (2).

Maintenance

The design of the shallow canal minimized capital costs in the initial construction, but required constant maintenance as silt and other materials built up along the bottom of the canal. The tolls collected from users provided a stable source of funds for the constant maintenance.

Feeder Canals

After construction of the canal, property owners not close enough for direct access to the water petitioned for feeder canals. The feeder canals opened large land areas to intense development and productivity. The rationale for building the segments included the "public good," even though the costs for these smaller segments of infrastructure were greater than the costs for an equivalent length of the original canal, and each new segment only served the needs of the surrounding property owners (2).

Financing Strategies

After supper on board an Erie Canal packet boat, passengers selected berths based on order of arrival. Three tiers of bunks were erected along each side of the main cabin, with late arrivals sleeping on the floor or outside on the cabin roof (*8*, p. 638).

The lack of interest from the federal government and the keen competition among states and cities to capture a share of future growth led New York State to several financing innovations for the canal project. The state championed the project, instead of allowing the canal to become an entirely private venture.

Private investors, however, were welcome to invest in the new infrastructure. The toll system and the pent-up demand for services immediately created a surplus of cash, allowing the state to deal with other financial crises.

One of the most interesting financing strategies involved compensation of land owners. Land used for the canal had to be purchased, but if the property owner's benefits from access to the canal were greater than the price of the land, the state was not required to pay for the land.

The rule encouraged new land uses or conversions of activities where infrastructure investment offered the most potential, illustrating the value added by the transportation infrastructure. Farmers who continued to farm as they had done before the canal were assumed to have received the value of their land in new crop yields and to have forgone the greater profit of selling the land at its increased value.

Another interesting financing practice occurred when the railroads began competing for the goods moving on the Erie Canal. At first, only passengers were allowed to ride on the railroads. However, because of the canal's seasonal limitations, freight was allowed to move on railroads during the winter. The next step was to charge rail shippers the tolls that would have been paid for using the canal (3).

Demand and Land Use

Markets and Frontiers

The canal was originally envisioned as a means of transporting freight. Farmers along the canal would have access to markets in New York City, and from there, goods could be shipped to global markets. In addition, merchants in New York City would have access to prospering farmers for sales of products.

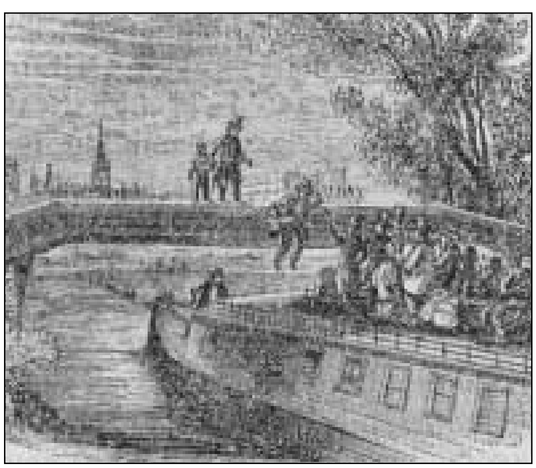
The canal offered a means of transporting households to the new frontier of the West. The flow of household goods was critical to the long-term success of the westward expansion of New York State and the young nation. To encourage this traffic, no tolls were charged for moving household goods on the canal—the more goods settlers could take along, the more likely they were to remain out West (2).

Changing Landscapes

Also contributing to the underestimation of demand was the change in land uses as transportation costs along the canal decreased. With new accessibility to markets, farmers moved from subsistence farming to market-oriented crops. Success with newly expanded crops increased incomes and put cash in farmers' pockets through sales to the distributors who moved the harvest along the supply chain.

Warehouses built along the canal allowed commodity brokers to regulate the flow of goods. Increased wealth also changed the nature of the landscape as services and new retail uses became viable.

The increase in economic activities along the canal (e.g., with canal-related jobs such as lock keepers and workers to manage the tow mules) also contributed to the increase in cash transactions. Banks were established to hold the new wealth. Banks also gained valuable expertise through the preparation and management of the canal loan programs in the 1820s,



Passengers failing to arrive in time for the boat's departure could walk to the nearest bridge over the canal, wait for the boat to pass under, and then leap onto the boat, three or four feet below (*8*, p. 626).

Photo by Catherine Lawson, 2002.

At the juncture of the Erie Canal with the Hudson River in Albany, New York, sign provides brief history, part of a promotional and educational outreach.

adapting the financial savvy to the underwriting of railroad investments in the 1840s (*1*).

Several typical New England factories developed on the Erie Canal, including textile mills and the Remington Arms plant at German Flats. Most of the industries centered on processing harvests from farm and forest, including rapidly growing shipments of grain from the West. The flour mills of Buffalo, Lockport, Rochester, Oswego, and Fulton were nationally known (*7*).

Passenger Travel

Although built to move freight, the Erie Canal soon attracted passengers. Canal travel offered a smooth-riding means of transportation, compared with horse-drawn modes over terrain. In addition, the service was more frequent, with several canal boats passing most towns along the canal every day. Stage coaches were less frequent and less reliable (*2*).

Passengers sought a variety of services—short trips, long trips, trips for leisure, trips for business, trips to gain knowledge of the natural features of the West, and trips that never ended for households that lived on canal boats. Each type of trip required a different kind of boat or service.

A special vessel, known as a canal packet, offered tourists an amazing ride. Only 78 feet long and 14-1/2 feet wide, the packet could carry up to 40 passengers, who could sleep on board, paying 5 cents a mile, including the cost of a bunk and meals (*8*). In the morning the central cabin sleeping area served as a breakfast room, then converted into a sitting room, with comfortable chairs and entertainment, including live music, and changed back to a dining area for lunch and again for dinner. Canal packets were an early version of "mixed use" development.

The regularity of the services soon led to abuse. Townspeople along the canal, knowing the schedules, would leap off low bridges onto the packet boats just before meals, helping themselves to a meal and then paying the captain 5 cents to stop momentarily so they could debark. To stem this practice, packets charged all passengers a flat, base fee of 15 to 25 cents.

Often more than 100 passengers would ride a packet during the daytime, and at night if the bunks were full, many would sleep outside on the decks. Riding on the outside of the boat provided some with the educational opportunity to view aspects of the local geology revealed through the canal construction and the cuts in the terrain.

Time and Distance

The canal raised expectations of traveling easily and quickly from one location to the next, of shipping and buying goods inexpensively, and of communicating with family and friends through speedy mail deliveries (*2*). However, the congestion—primarily caused by lock operations—occasionally provoked some captains, pressured to move goods quickly, into "canal rage" (*3*).

The congestion delays for passengers often occurred at the locks in Albany. Leaving female companions behind on the packet boat, male travelers would take a fast ride by stagecoach to transact business in Schenectady, demonstrating the concept of the "value of time."

The canal boats also speeded mail from New York City to the Old Northwest. People who moved out West were able to remain in regular contact with relatives, reducing the pain of separation (*2*).

Next Chapters

Expansion and Advances

The immediate success of the Erie Canal prompted a plan to expand the system. In 1835, the canal was enlarged to 70 feet wide and 7 feet deep. The stone-reinforced infrastructure required new construction technologies. Incremental implementation again had allowed time for the development of the technology necessary to add capacity.

Despite the expanded capacity, more and more canal traffic began to shift to the railroads. At the turn of the century, a modernization plan called for the creation of the Barge Canal to regain a competitive edge for water transport. The use of cement, the replacement of animal power with towboats, additional expansion of the canal, and new electrical technologies were all strategies to make the waterway competitive (*9*).

The purpose of the Barge Canal was to accommodate 1,000-ton barges. The new facility opened in

Double locks at Beech Street, Syracuse, New York, date back to 1835 enlargement of canal (circa 1900).

Photo courtesy of Erie Canal Museum, Syracuse, New York.

1918 and operated until the late 1950s.

Recent Initiatives

In 1995, steps were under way to develop a New York State Canal Recreation Plan to foster development of a recreational system (*10*). In 1997, the U.S. Department of Housing and Urban Development created a pooled fund for economic development grants and a guaranteed loans program.

A new approach, the Canal Corridor Initiative, created a partnership of federal and local governments and the private sector. The initiative calls for a series of Community Development Block Grants for small cities to begin neighborhood revitalization, economic development, and improvements in facilities and services, using the canal as a unifying theme (*11*). In addition, the canal offers opportunities for on-the-water and along-the-water recreation.

Lessons Learned

The history of the Erie Canal is a fascinating story of achievements, rewards, and reuse of a transportation facility. The story also offers today's transportation planning community several lessons:

◆ *Education is a critical link to real-world applications*. The Erie Canal exemplifies the importance of education, research, and the sharing of ideas to develop a successful transportation system. These efforts produced cost savings through innovation, even as the project was under way. Universities can explore solutions for long-range planning challenges in partnership with local, state, and federal agencies.

◆ *Creative financing strategies should involve a broad set of stakeholders*. The various strategies to finance the Erie Canal illustrate how private-sector investors can share in the risks and rewards of new infrastructure, how system users can ensure infrastructure performance through a long-term commitment to tolls, and how it may be appropriate to tax properties for accessibility within the "geography of benefits." In addition, payments for land used for transportation projects can deduct the value of the new accessibility gained by the seller.

◆ *Understand the range of trip purposes and potential uses*. Estimating demand requires a careful examination of who, what, where, and why businesses and citizens will use a transportation facility. The Erie Canal served a variety of trip purposes, including many new trips from previously untapped commercial and leisure markets. Differentiated vessels, service frequencies, and routings all function best when meeting the needs of users. Moreover, users quickly become spoiled by a higher quality of transportation service and demand more.

PHOTO COURTESY OF ERIE CANAL MUSEUM, SYRACUSE, NEW YORK.

Barge Canal (circa 1940).

References

1. Cornog, E. *The Birth of Empire: De Witt Clinton and the American Experience, 1769–1828*. Oxford University Press, New York, 1998.
2. Sheriff, C. *The Artificial River: The Erie Canal and the Paradox of Progress, 1817–1862*. Hill and Wang, New York, 1996.
3. *The Erie Canal*. Video presentation, The History Channel, 2001.
4. Shaw, R. E. *Erie Water West: A History of The Erie Canal 1792–1854*. The University Press of Kentucky, Lexington, 1966.
5. Phelan, T., and R. T. Carroll. *Hudson Mohawk Gateway: An Illustrated History*. American Historical Press, Sun Valley, Calif., 2001.
6. Rezneck, S. A Traveling School of Science on the Erie Canal in 1826. *New York History*, Vol. 40, No. 3, 1959, pp. 255–289.
7. Meinig, D. W. *The Shaping of America: A Geographical Perspective of 500 Years of History, Volume 2: Continental America, 1800–1867*. Vail-Ballou Press, Binghamton, N.Y., 1993.
8. Dunbar, S. *A History of Travel in America*. Van Rees Press, New York, 1937.
9. O'Malley, C. T. *Low Bridges and High Water on the New York State Barge Canal*. North Country Books, Inc., Utica, N.Y., 1991.
10. *Canal Corridor Initiative, Connecting Communities: A Framework for Comprehensive Development*. U.S. Department of Housing and Urban Development and Office of Community Planning and Development, 1996.
11. New York State Canal Recreationway Commission. *New York State Canal Recreationway Plan* [Draft]. New York Thruway Authority and the New York State Canal Corporation, 1995.

Websites

Erie Canal Museum, www.eriecanalmuseum.org/

New York State Canal Corporation, www.nycanal.com/

New York State Canals, www.canals.state.ny.us/

Measuring the Service Levels of Inland Waterways

Alternative Approaches for Budget Decision Making

DAVID V. GRIER

The author is with the U.S. Army Corps of Engineers, Institute for Water Resources—Navigation, Alexandria, Virginia.

Tow entering Melvin Price Locks and Dam, Mississippi River, near Alton, Illinois.

The federal government, through the U.S. Army Corps of Engineers, has taken the lead in developing and maintaining the nation's extensive inland waterways infrastructure with a combination of dredging, river training works, and navigation locks and dams. The government constructs inland navigation improvements if a detailed economic analysis shows that the benefits will exceed the costs over a 50-year project life.

The Corps operates and maintains nearly 12,000 miles of inland and intracoastal waterways with more than 200 locks and dams, at an annual cost of more than $450 million. Each year limited operations and maintenance (O&M) funds are stretched for the upkeep of an aging inland infrastructure.

Budget proposals therefore focus O&M resources on projects that serve the greatest volume of commerce and reduce funding for projects that do not meet a specified threshold. But what measures are appropriate for assessing waterway service levels and for determining a threshold? How should the federal government weigh continued interest in these projects? What is the return on the federal investment, and what are the consequences of reducing the investment?

Vital System

The U.S. inland waterways are vital in moving bulk cargoes and manufactured goods for foreign and domestic commerce. The inland waterways system centers on the Mississippi River and its major tributaries, including the Ohio, Illinois, Missouri, Arkansas, Tennessee, and Cumberland Rivers (Figure 1). Navigation infrastructure improvements along these rivers have provided a channel—at least 9 feet deep—into the nation's heartland, connecting the Gulf Coast with the coal and steel industries of Pittsburgh, Pennsylvania; the grain exporters of the Twin Cities, Minnesota; and the manufacturing centers around Chicago, Illinois.

The river system connects with the Gulf Intracoastal Waterway (GIWW) at New Orleans, Louisiana, providing the petrochemical industry in Louisiana and Texas with a protected, shallow-draft channel along the Gulf Coast. The Atlantic Intracoastal Waterway (AIWW) and the Columbia–Snake Waterway are separate shallow-draft systems serving the Atlantic Coast and the Pacific Northwest, respectively.

The inland waterways system allows the competitive movement of huge quantities of liquid and dry bulk cargoes between deepwater ports and distant points of production or consumption in the nation's interior. In recent years, U.S. inland waterways traffic has approximated 630 million tons annually—and about 300 billion ton-miles (*1*)—accounting for about 15 percent of total intercity commerce by volume. More than 50 percent of U.S. grain exports depend on this river network (2).

Principal commodity groups on inland waterways include coal, petroleum, farm products, chemicals, and crude materials, such as aggregates for construction and other minerals. Coal and petroleum are the largest commodity groups by volume at 167 million tons (27 percent) and 150 million tons (24 percent), respectively. Coal generates more than half the electricity produced in the United States, and the inland waterways transport about 20 percent of the nation's coal. Crude petroleum moves by waterways to refineries, particularly along the western Gulf Coast, and petroleum products are shipped to terminals throughout the inland waterways network.

However, if distance is factored in and commodities are measured on a ton-mile basis, farm products become the largest commodity group on the inland waterways at more than 31 percent of all ton-miles, with the shares of coal and of petroleum at 21 percent and 13 percent, respectively (Figure 2). This statistic highlights the role of inland waterways in providing low-cost transport for U.S. grain exports, which travel greater average distances by river than other commodity groups, from farms in the Midwest and eastern Great Plains to deepwater terminals on the Lower Mississippi.

Funding Decisions

The federal government develops and maintains the inland waterways infrastructure with a combination of dredging, navigable dams, river training works, and 276 chambers at 230 lock sites (*3*). The estimated replacement value of these improvements is more than $120 billion, and annual O&M costs exceed $450 million.

Inland waterways O&M is funded through Corps appropriations from general federal revenues. The annual capital investment in new and replacement locks and dams and other infrastructure improvements is $200 million to $250 million. Funding for most of these projects is shared evenly between general federal revenues and the Inland Waterways Trust Fund (IWTF). The inland waterways towing industry generates IWTF revenues by paying a fuel tax of 20 cents per gallon.

As the inland waterways system ages, the need for maintenance increases. Nearly half of the locks and dams have exceeded their 50-year design lives. But federal budget constraints have kept O&M funding relatively static in terms of constant dollars, stretching funds over a growing portfolio of aging projects and postponing critical maintenance. The Administration's Fiscal Year (FY) 2003 budget request, for example, has omitted about $108 million in O&M for "low commercial-tonnage inland waterway projects" (*4*).

In addition, the construction schedules of many larger replacement locks are being delayed, increasing congestion and reducing project benefits. Other authorized projects may not start as planned. Yet replacement or major rehabilitation at many locks is necessary to preserve the integrity of the inland navigation system.

Budget constraints have necessitated attempts to prioritize O&M and construction funds among competing navigation and civil works projects. The President's Budget Request for FY 2003 uses O&M cost per

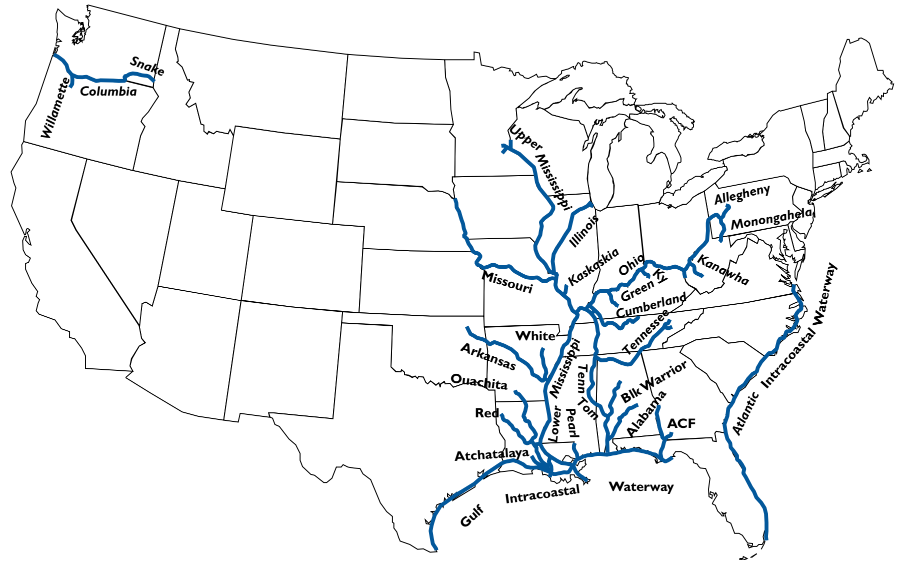


FIGURE 1 U.S. inland and intracoastal waterways.

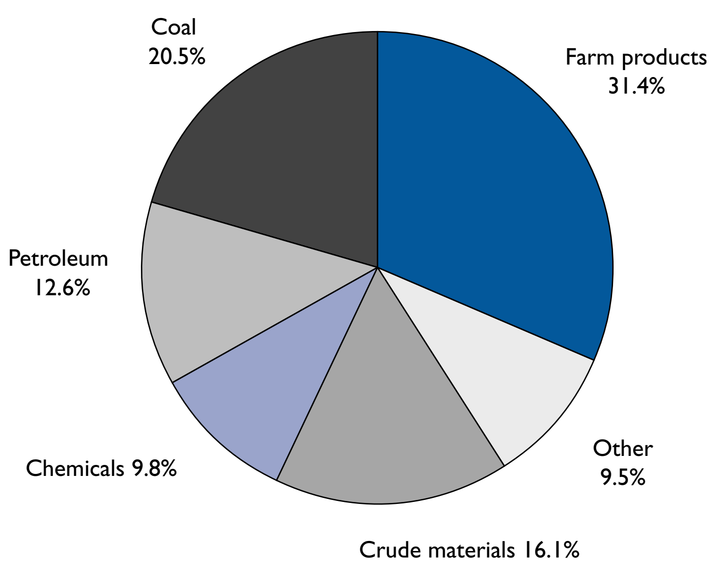


FIGURE 2 U.S. inland waterways ton-miles by commodity group (305 billion ton-miles total), 1999.

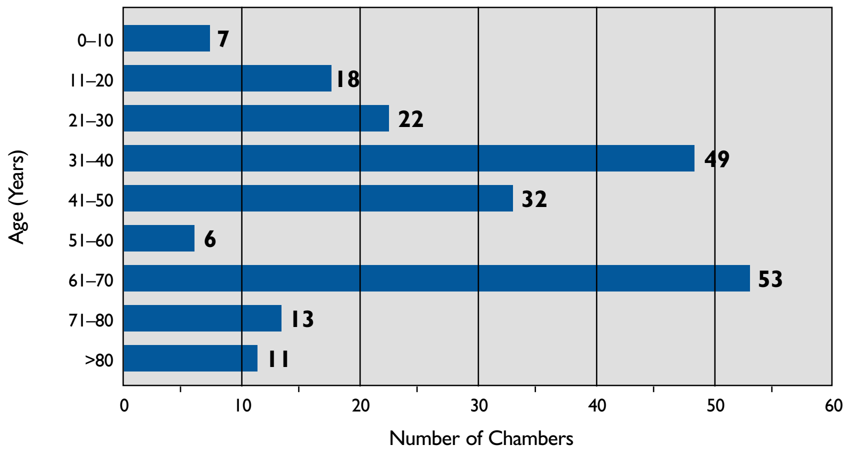


FIGURE 3 Aging inventory of inland waterways locks.

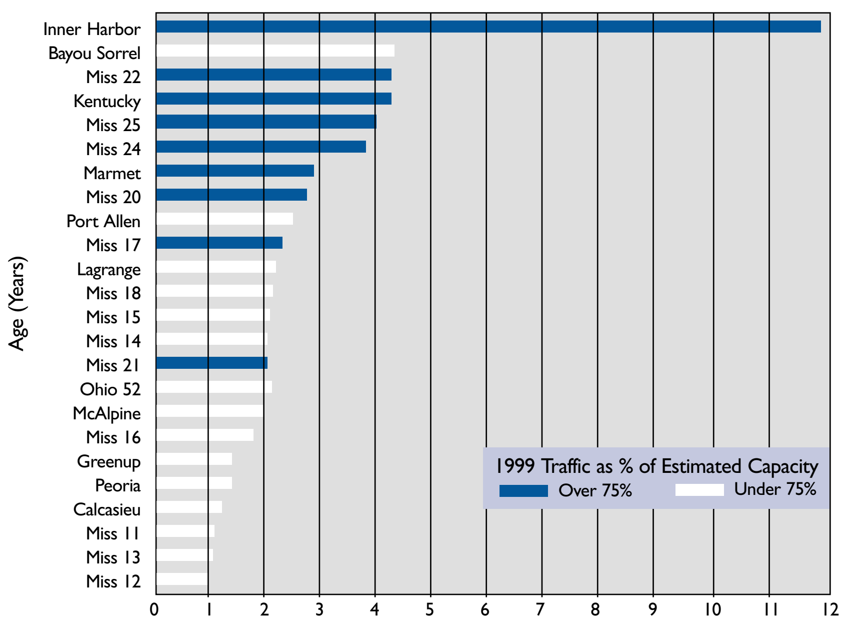


FIGURE 4 Average hours of delay at locks, per tow, 1990–1999.

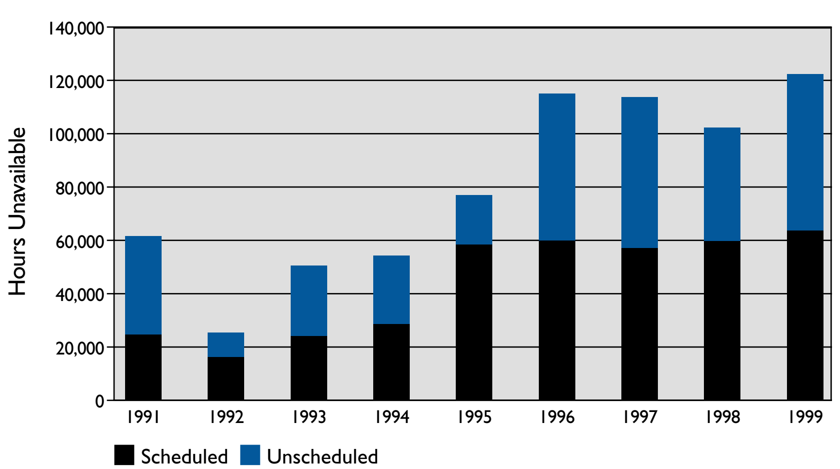


FIGURE 5 Total hours of scheduled and unscheduled navigation lock unavailability.

ton-mile of cargo to allocate "funds to those waterways that provide the greatest economic return and [to] substantially reduce funding for those that provide minor commercial navigation benefits" (*5*). This decision directs O&M funding to larger mainstem waterways and away from smaller tributary waterways.

Infrastructure Challenges

The aging U.S. inland waterways infrastructure requires increased maintenance, major rehabilitation, and modernization. Many facilities were constructed in the 1930s (Figure 3) and are undersized for today's typical inland waterway tow of 15 or more barges.

Some modernization has been under way since the 1950s—mainly along the Ohio River—with older 600-foot lock chambers enlarged or replaced with new 1,200-foot facilities that can accommodate 15-barge tows. But 600-foot lock chambers still dominate other principal high-volume waterways—such as the Upper Mississippi and Tennessee Rivers and the GIWW and Illinois Waterway—requiring tows to be "cut" into at least two sections to pass.

Cutting tows increases processing times to two hours or more at each lock, compared with a half-hour to pass through a 1,200-foot lock. Although increasing the transportation costs, the longer processing times are generally manageable during lower traffic periods. But as traffic volumes grow—especially during seasonal peaks—lengthy processing times produce huge and costly queues of tows at each lock. The lock delays totaled nearly 500,000 hours in 1999, with an estimated cost to industry of about $160 million (*6*).

The impacts of undersized locks and increasing traffic delays are shown in Figure 4, which displays average hours of delay per tow at 24 major locks between 1990 and 1999. The average delays at these facilities ranged from about 1 hour at Lock and Dam 12 on the Upper Mississippi to nearly 12 hours for each tow at the New Orleans Inner Harbor Lock on the GIWW.

Several locks on the Upper Mississippi now average more than 4 hours of delay per tow, and delays during the autumn peaks often surpass 24 hours per tow. Annual tonnage through 9 of the 24 lock facilities exceeds 75 percent of the lock capacity, leaving little room to accommodate projected system traffic growth of about 1.3 percent annually through 2020.

Another challenge of an aging infrastructure is the higher maintenance. In the next 10 years more than half the locks on the system will exceed their 50-year engineering design lives. Yet in terms of constant dollars, Corps O&M funding for navigation has remained at 1977 levels, creating a backlog for maintenance and rehabilitation.

Large mixed-commodity tow on Lower Mississippi River.

Deteriorated wall at Monongahela River Lock and Dam 3, which opened in 1907.

Tow cuts passing through Lock and Dam 22 on Upper Mississippi River.

The aging of the inland navigation infrastructure and the budget constraints for ongoing maintenance and repairs have increased the scheduled and unscheduled downtime at locks. Lock unavailability has more than doubled since the early 1990s, from about 60,000 hours to more than 120,000 hours annually (Figure 5).

Shippers can prepare for scheduled lock downtime by stockpiling or increasing shipments. Unscheduled downtime, however, disrupts shipments and contractual commitments, forcing shippers to scramble for alternatives that typically cost much more.

Funding Challenges

Another concern is the uncertainty of O&M funding, caused by a lack of consensus between the executive and legislative branches. The Administration's FY 2002 budget request included about $406 million in O&M funding for 23 specific inland waterways projects, but in the final appropriation for FY 2002, Congress increased the requested amount by nearly 9 percent to $442 million. Yet the Administration's FY 2003 budget request would reduce O&M by more than 6 percent, and individual projects would face more drastic reductions.

The Administration's request, for example, would reduce funding for 12 tributary waterways—in particular, the Apalachicola–Chattahoochee–Flint (ACF) system, the Alabama River, the Allegheny River, the Red River Waterway, the Ouachita–Black system, and the AIWW—by amounts ranging from 5 to nearly 90 percent (*7, 8*). Congress had increased O&M funding for most of these projects in the final FY 2002 appropriation—in the extreme case of the ACF, Congress authorized a more than tenfold increase.

Alternative Funding Criteria

The reduction in O&M funding for these projects reflects lower commercial use in ton-miles. The proposed FY 2003 budget would reduce the O&M for 12 tributary waterways by about one-third, from $96 million in FY 2002 to $61 million. In addition, small funding decreases affect three mainstem waterways—the Ohio and Tennessee Rivers and the GIWW.

Generally, projects with less than 1 billion ton-miles suffered the most drastic reductions in O&M funds. Until recently, the Corps' Waterborne Commerce Statistics Center generated the only published annual data on waterway use, in tons and ton-miles.

Flawed Metric

But the number of ton-miles on a waterway has flaws as a metric for budget decisions, especially in comparing waterways. Waterways act as a system—the same shipment can move over several waterway segments. The ton-mile figure only applies to traffic on a single waterway and only for the distance traveled on the waterway—the figure does not encompass the entire movement of shipments.

By not capturing systemwide impacts, this approach minimizes the importance of tributary waterways. Just as a trip on neighborhood streets is usually a small but important part of a car journey, the trip on the tributaries is usually a small part of the journey from producer to consumer—the tributary traffic joins the mainstem and becomes part of the more impressive statistics for the waterway "Interstates."

In a real-world example, a barge load of 1,500 tons of coal leaves a mine tipple on the Kanawha River, in West Virginia, for the recently opened Red River Waterway in Louisiana. Unpublished data from the 1998 Waterborne Commerce Statistics Center document the shipment as follows:

River	Miles	Tons	Ton-miles	Percent
Kanawha	83	1500	124,500	5.0%
Ohio	715	1500	1,072,500	43.2%
Mississippi	650	1500	975,000	39.3%
Atchafalaya	6	1500	9,000	0.4%
Red	200	1500	300,000	12.1%

TOTAL 1,654 1500 2,481,000 100.0%

The mainstem, high-use Ohio and Mississippi Rivers are credited with 83 percent of the ton-miles. Yet the movement could not have occurred without access to the Kanawha River and demand by a coal customer on the Red River, which are credited with only 5 and 12 percent of the movement, respectively.

The ton-miles metric, therefore, penalizes shorter waterways. Some tributaries serve as short extensions of a mainstem waterway. For example, to approach the 1 billion ton-mile threshold for full O&M funding in the FY 2003 budget request, the 36-mile long Kaskaskia River in Illinois would have to generate nearly 28 million tons of cargo—more than the port of Seattle, Washington, or more than the ports of Savannah, Georgia, and Miami, Florida, combined.

Better Alternative

A better measure may be the system ton-miles associated with a waterway. This measure became available only recently and has not yet been calculated for all waterways.

System ton-miles measure a waterway's contribution to the whole waterways system. System ton-miles are computed by identifying every commercial cargo-carrying vessel that has plied the inland waterway and summing the products of the tons times the total trip-miles for each vessel trip. The total trip-miles represent the total distance from origin to destination.

For example, according to published statistics, the Red River handled 335.5 million ton-miles in 1999. That statistic documents the Red River portion of all trips to or from the Red River. However, if the total ton-miles from cargo origin to destination are calculated for Red River traffic, those 335.5 million ton-miles would translate into 2.4 billion ton-miles throughout the system that depend on terminals on the Red River.

In other words, terminals on the Red River generate more than seven times the ton-miles credited to the Red River in published statistics. Although 19 tributary waterways carry about 4.5 percent of inland waterways ton-miles, terminals on the tributaries generate more than 22.5 percent of the ton-miles moving throughout the system.

The average ton-miles and system ton-miles for 14 tributary inland waterways for 1995 to 1999 are shown in Table 1 (*9*). Major mainstem waterways carry most of the system ton-miles. Tributary waterways feed cargo onto the mainstem waterways, which then convey the cargo to distant terminals or ports for export.

The system ton-miles metric reveals the importance of tributary waterways. Several waterways that handle substantially less than 1 billion ton-miles directly—including the Green, Red, Missouri, Snake, and Allegheny Rivers—in a systemwide context generate substantially more than 1 billion ton-miles (Table 1). Others still fall short of the 1 billion ton-miles mark, but nevertheless generate systemwide traffic far greater than the ton-miles on the tributary waterway. An extreme example is the Kaskaskia, which handles only about 20 million ton-miles but generates nearly 420 million ton-miles as the cargo moves throughout the system—a figure 21 times greater.

Smaller tributaries—particularly the Kaskaskia, ACF, Allegheny, Kentucky, and Willamette—generally have much higher costs per ton-mile than mainstem waterways (Table 1). However, in terms of O&M cost per system ton-mile, several of these waterways compare more favorably—specifically the Kaskaskia and the Allegheny, and to a lesser extent, the ACF.

Although introducing the concept of a waterway's contribution to the network as a whole, the system ton-miles metric still encourages a comparison of waterways for decision making about O&M funding. The implication is that a waterway's ranking determines its relative worthiness for federal investment. This approach may hold a waterway to a higher standard than the initial economic analysis. In effect, to qualify for continued O&M, a waterway must generate and sustain commerce at levels not envisioned by planners and for which it was not designed and constructed.

TABLE 1 Inland Waterway Operations and Maintenance Costs Compared to Ton-Mile Measures

Selected Tributary Waterway	River Miles	Average O&M 1995–1998 ($000)	Average Ton-Miles 1995–1999 (billions)	Average System Ton-Miles 1995–1999 (billions)	O&M Cost per Ton-Mile (cents)	O&M Cost per System Ton-Mile (cents)
Willamette	26	887	0.00	0.01	25.48	11.85
Kentucky	82	3,285	0.01	0.02	23.28	13.42
Allegheny	72	9,932	0.06	1.42	16.61	0.70
ACF	289	7,738	0.05	0.19	14.66	3.97
Kaskaskia	36	1,905	0.02	0.42	10.18	0.46
Alabama	305	5,708	0.06	0.10	9.50	5.51
AIWW/IWW	1,142	21,886	0.28	0.61	7.74	3.56
Ouachita/Black	332	6,472	0.20	0.73	3.18	0.88
Red	212	8,720	0.29	2.13	2.97	0.41
White	296	1,906	0.08	0.30	2.52	0.63
Snake	141	5,738	0.42	1.75	1.37	0.33
Missouri	732	9,844	0.74	1.80	1.33	0.55
TennTom	234	13,559	1.47	4.96	0.93	0.27
Green	109	1,792	0.29	2.35	0.63	0.08

(NOTES: ACF = Apalachicola–Chattahoochee–Flint, AIWW = Atlantic Intracoastal Waterway, IWW = Intracoastal Waterway–Jacksonville to Miami. SOURCE: U.S. Army Corps of Engineers.)

Transportation Savings

Perhaps a more appropriate way to assess the return on continued O&M funding of lower-use tributaries would be to measure the impact in terms of transportation savings—a basic step in a Corps benefit analysis of any navigation project proposal. Does a waterway continue to produce transportation savings in terms of national resources, and do these savings exceed the cost?

The analysis requires a detailed review of the costs of barge and alternate mode transport, by origin and destination, for all commodity movements on a tributary. Other project benefits also should be reassessed, as well as the impacts that changes in O&M may have on other project purposes. Such a study would be appropriate before considering whether or not to maintain a waterway for navigation, or before divestiture to a nonfederal entity—which was the fate of the Fox River in Wisconsin and of the upper reaches of the Kentucky River.

Some rough estimates of transportation savings are possible using national-level analyses prepared by the Tennessee Valley Authority (TVA) from regional surveys. TVA has estimated the average transportation savings by commodity group for inland waterways traffic annually since the late 1990s. The nationwide averages are based on surveys comparing barge and rail linehaul transportation costs for more than 8,000 origin–destination pairs throughout the inland waterway system. For 1999, TVA estimated that savings ranged from $6.92 per ton for coal to $29.65 per ton for chemicals and averaged $10.54 per ton for all cargo.

Applying these average savings by commodity to traffic on the tributaries provides a rough estimate of the transportation savings for the waterway. This macro analysis may not represent the marginal transportation savings for traffic on individual waterways. However, most of the tributary traffic moves to and from points throughout the waterway system and also enjoys the economies of scale associated with mainstem waterways—a reason for using national averages until more detailed data are available.

Table 2 displays average waterways O&M costs for 1995 to 1998, as well as estimates of transportation savings, for 14 selected tributary waterways. The savings estimates were calculated by multiplying average waterway tons for each commodity by TVA's transportation savings figures. Commodity-group tons were averaged for 1995 to 1999.

This estimate of transportation savings suggests that many tributary waterways may produce savings that are far greater than the O&M expenditures. The comparison of savings to O&M is particularly significant for the Green, Willamette, Snake, Missouri, and the Tennessee Tombigbee Waterway (TennTom)—all of which produce estimated savings of 6 to 27 times

TABLE 2 Average Waterway Operations and Maintenance Cost and Estimated Transportation Savings, 1995–1999

Selected Tributary Waterway Segment	Average O&M 1995–1998 ($million)	Average Tons 1995–1999 ($million)	Average Savings per Ton ($)	Total Savings ($million)	Ratio of Estimated Savings/ O&M Cost
Green	1.79	6.4	7.5	48.1	26.86
Williamette	0.89	1.2	7.8	9.4	10.59
Snake	5.74	6.1	9.6	58.0	10.11
Missouri	9.84	7.9	8.9	70.8	7.19
TennTom	13.56	8.2	10.5	86.1	6.35
Red	8.72	2.3	10.5	24.4	2.79
AIWW/IWW	21.89	4.3	18.3	78.1	3.57
Kaskaskia	1.90	0.8	7.7	6.6	3.45
Allegheny	9.93	3.7	9.0	33.1	3.33
Ouachita/Black	6.47	1.5	11.7	18.1	2.80
White	1.90	0.5	9.6	4.9	2.58
Alabama	5.71	0.7	11.1	7.6	1.33
ACF	7.74	0.5	14.3	7.1	0.92
Kentucky	3.28	0.3	7.3	1.9	0.58

(NOTES: AIWW = Atlantic Intracoastal Waterway, IWW = Intracoastal Waterway–Jacksonville to Miami. SOURCES: U.S. Army Corps of Engineers; Tennessee Valley Authority, 1999 data.)

their average O&M expenditures.

Figure 6 displays O&M cost and estimated savings for 11 tributary waterways targeted for O&M reductions in the FY 2003 budget request and highlights the substantial estimated transportation savings for several of the waterways, including the Missouri, TennTom, and AIWW–Intracoastal Waterway. Although not as dramatic, estimated savings are more than triple the O&M costs for the Allegheny and Kaskaskia, and more than double for the Red, Ouachita, and White.

The figure also shows marginal estimated savings for the Alabama and savings less than O&M costs for the ACF and Kentucky. However, these estimates are based on national averages and do not capture unique characteristics of localized movements on these

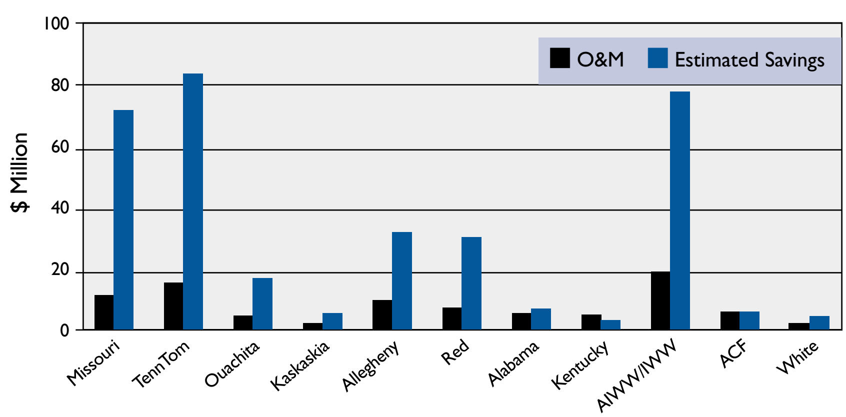


FIGURE 6 Operations and maintenance (O&M) and estimated transportation savings on selected tributary waterways, 1995–1999.

Aerial view of Lock and Dam 15, Mississippi River, Rock Island, Illinois.

tributary waterways.

This macro approach is analytical—ideally, transportation savings should be evaluated in terms of marginal savings for actual and alternative modes by origins and destinations. But the approach assesses the value of tributary waterways as a return on an investment of federal resources.

"Paying Their Way"

Tributaries play an important role within the national waterways system, linking more remote communities and regions with the mainstem waterways. Traffic that originates or terminates on 19 tributaries generates more than 22 percent of total inland waterways ton-miles and probably well more than 25 percent of inland waterways fuel tax revenues. Tributaries also may serve other public purposes, such as flood protection, hydropower, water supply, and recreation.

Tow on the Tennessee–Tombigbee Waterway.

Metrics such as waterway ton-miles are used to rank waterways to set priorities for limited O&M funds. This approach is problematic, failing to capture a tributary's contributions to traffic moving throughout the waterways. Even an approach that considers system ton-miles associated with tributary waterways may set demanding traffic thresholds for which the waterway facilities were never planned, designed, or authorized.

However, estimates of transportation savings—which need more detailed study—would provide a metric more akin to the purposes for which waterway improvements were initially authorized and constructed. Estimated transportation savings by waterway, extrapolated from national averages by commodity group, suggest that nearly all tributary waterways "pay their way" several times over as a return on the federal investment in O&M. A few, however, show marginal or negative returns on O&M expenditures.

The problem for decision makers may not be whether the lower-use tributary waterways are serving navigation in the federal interest. Instead, the problem may be that O&M funds are constrained and cannot support all the waterways that merit continued federal investment.

References

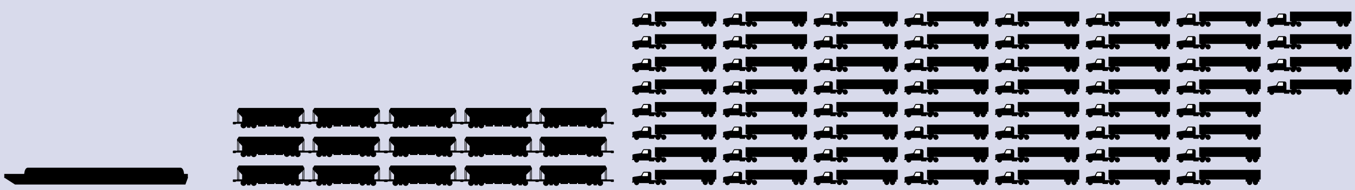
1. *Waterborne Commerce of the United States.* U.S. Army Corps of Engineers, annual.
2. *Transportation of U.S. Grain.* U.S. Department of Agriculture, March 1998.
3. *The U.S. Waterway System: Transportation Facts.* U.S. Army Corps of Engineers, Navigation Data Center, Dec. 2001.
4. Complete Statement of Lieutenant General Robert B. Flowers, Chief of Engineers, Before the Subcommittee on Energy and Water Development, Committee on Appropriations, U.S. House of Representatives, on Civil Works Program Budget, Fiscal Year 2003. U.S. Army Corps of Engineers, Feb. 27, 2002.
5. Corps of Engineers: Civil Works. In *Fiscal Year 2003 Budget of the United States Government*. Executive Office of the President, p. 296. www.whitehouse.gov/omb/budget/fy2003/pdf/budget.pdf/.
6. Lock Delay Cost Estimates. U.S. Army Corps of Engineers, Institute for Water Resources, presented at Inland Waterways Users Board Meeting No. 39, Davenport, Iowa, July 18, 2001.
7. House Report 107-258: Making Appropriations for Energy and Water Development for the Fiscal Year Ending September 30, 2002, and for Other Purposes: Conference Report. U.S. House of Representatives, Oct. 30, 2001.
8. *Fiscal Year 2003: Civil Works Budget for the U.S. Army Corps of Engineers.* U.S. Department of the Army, Office of Assistant Secretary of the Army, Civil Works, Feb. 2002.
9. System Ton-Miles for Major Waterways. U.S. Army Corps of Engineers, Navigation Data Center. www.iwr.usace.army.

Comparison of Inland Waterways and Surface Freight Modes

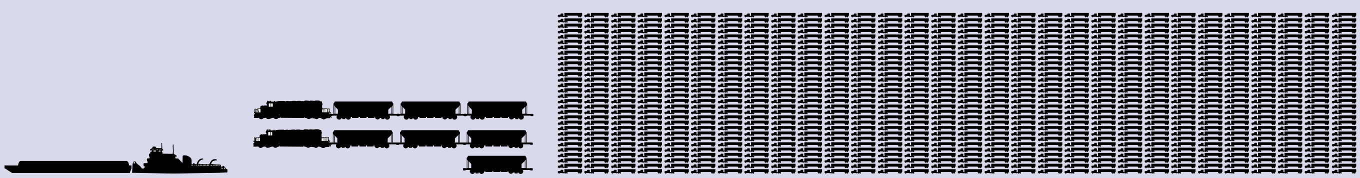
Cargo Capacity

Mode	barge	15-barge tow	jumbo hopper car	100-car unit train	large semitrailer
Vehicle weight in tons	1,500	22,500	100	10,000	25
Capacity in bushels	52,500	787,500	3,500	350,000	875
Capacity in gallons	453,600	6,804,000	30,240	3,024,000	7,500

Equivalent Units

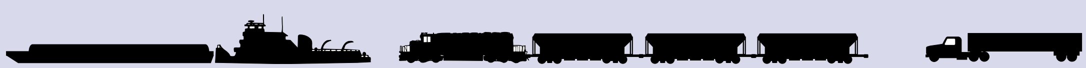


1 barge = 15 jumbo hoppers = 60 large semitrailers



1 15-barge tow = 2-1/4-unit trains = 900 large semitrailers

Equivalent Lengths



Equivalent units	15-barge tow	2-1/3-unit trains	900 large semitrailers
Length in miles	0.25	2.75	36*

Shipping Rates

Mode	*Cents per ton-mile*
Barge	0.97
Rail	2.53
Truck	5.35

Fuel Consumption Rates

Mode	*Ton-miles per gallon*
Barge	514
Rail	202
Truck	59

Emissions (lbs.) Produced in Moving 1 Ton of Cargo

Mode	*Hydrocarbon*	*Carbon Monoxide*	*Nitrous Oxide*
Towboat	0.09	0.20	0.53
Rail	0.46	0.64	1.83
Truck	0.63	1.90	10.17

* Assuming 150 feet between vehicles.

SOURCES: River Transportation Division for Planning and Research Division, Iowa Department of Transportation; U.S. Army Corps of Engineers; Emission Control Lab, Environmental Protection Agency.

River Efficiency, Fuel Taxes, and Modal Shifts

Tennessee Valley Authority Model Assists Policy Makers

LARRY G. BRAY, CHRISMAN A. DAGER, RONALD L. HENRY, AND M. CAROLYN KOROA

The authors are with the Tennessee Valley Authority, River Systems Operation and the Environment, Knoxville.

With the projected closing of Chickamauga Lock on the Tennessee River, seven miles upstream from Chattanooga, measuring and increasing river efficiency has become a focus for the Tennessee Valley Authority (TVA). The closing of the strategic lock for replacement would eliminate navigation on the upper Tennessee River and would divert a significant volume of barge traffic to an already overcrowded highway network in East Tennessee.

TVA began studying ways to measure the economic and social costs of the intermodal traffic shifts that would result from the lock's closing. As part of its efforts, TVA developed a model for estimating river efficiency and fuel tax collections, based on Newstrand's pioneering model for estimating the environmental impacts of a modal shift (*1*). Improvements in the quality of U.S. Army Corps of Engineers navigation data also contributed to the development of TVA's River Efficiency Model (REM).

An offshoot of the REM produces estimates of fuel tax payments for the tow traffic on each river. As a result, payments into the Inland Waterways Trust Fund can serve as a check for the accuracy of the REM estimates. The absolute difference between the REM fuel tax estimates for 1996 to 1999—summed to a national total—and Trust Fund data published by the U.S. Treasury was 0.78 percent.

If the REM fuel tax estimates are accurate, then the river efficiency estimates also are accurate, because river efficiency is a linear transformation of the fuel tax. The REM can provide the first consistent national database of individual river efficiency estimates.

Chickamauga Lock and Dam is gateway to navigation on the upper Tennessee River but will be closed for replacement, leading to significant modal shifts of cargo.

Problem at Chickamauga

Created by an Act of Congress in May 1933, TVA currently owns 49 dams, 10 with navigation locks. TVA is responsible for capital expenditures planning, but the Corps takes primary responsibility for operation and maintenance at the locks and for dredging the navigation channels.

The Corps is constructing a 110-by-1,200-foot lock for TVA at Kentucky Dam and recently completed a draft Supplement Environmental Impact Statement for constructing a new, larger lock at Chickamauga Dam. Alkali–aggregate reaction (AAR)—which causes a physical expansion in concrete structures—has damaged the current single-chamber, 60-by-360-foot concrete lock.

Repairs and modifications to the hydropower units, spillway gates, and lock walls at Chickamauga Dam have attempted to alleviate problems associated with the concrete growth. However, TVA's dam safety officer has concluded that the lock will have to close for safety reasons around 2010. The Corps also has determined that the lock could not be kept open without expensive, major structural repairs that still would not extend the facility's life span significantly.

Although TVA and the Corps continue to study the AAR problem, the realization that navigation on the upper Tennessee River would cease without lock replacement led TVA economists to study the environmental impacts of modal shifts. Some shippers told TVA that a long or permanent closure of the lock would cause them to shift to truck or rail, and others said they would have to cease operations.

The U.S. Department of the Interior's guidelines for evaluating water projects state that the "federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the nation's environment" (2). Nonetheless, modal shifts caused by closing a lock or by congestion at a lock have been considered as providing a "national economic development" benefit.

Infrastructure studies[1] by the Corps and TVA are examining whether traffic moving by barge would do greater harm to the environment if diverted to another mode. Air pollution is a principal issue.

Previous Research

The REM derives from the work of the late Bill Newstrand at the Minnesota Department of Transportation (DOT). Newstrand contended that commercial barge transportation is often viewed as degrading the environmental quality of navigable rivers and that environmental reviews of water projects single out the impacts of barges and shoreside support facilities. In most studies, he noted,

> navigation has been viewed as a major contributor to environmental degradation of the waterways as precondition to the study. The possible environmental impacts of not developing a waterways project or not maintaining or improving an existing operation are never included in the environmental analysis. (*1*)

Newstrand's methodology estimated the impacts of a modal shift in terms of fuel use, exhaust emissions, truck tire disposal, and traffic accidents involving trucks.

[1] For example, the Missouri River Master Manual Review.

Tow approaching small lock, Upper Mississippi River. Small locks and higher average horsepower tows contribute to river's lower efficiency rating.

Although timely and innovative, Newstrand's model was limited by using national values for modal efficiency and ton-miles per gallon (tmpg) of fuel expended. Regional or specific values were not then available. Newstrand relied on data from a 1980 study by Eastman (*3*).

Eastman had estimated that barges were the most efficient inland transportation mode, crediting trucks with 60 tmpg, rail with 204 tmpg, and barges with 514 tmpg. More recent data do not support such an extreme fuel advantage for barges compared with rail, including one study that shows the efficiencies "converging" (*4*).

How the Model Works

The REM traces the fuel consumption and ton-miles traveled for each movement recorded in the Corps' Vessel Operation Reports.[2] The REM calculations require data from six Corps sources:

- ◆ The Waterborne Commerce Statistics Center (WCSC) "loaded" file, which includes the towboat number, the cargo, and the tons;
- ◆ The WCSC "lite" file, or towboat file, which contains the links traversed in each movement and the towboat number;
- ◆ The WCSC vessel file, which reports data on towboats operating in inland navigation, including horsepower, dimensions, and towboat draft;
- ◆ The Lock Performance Monitoring System file—the lock database—which contains information about tows passing through locks, including

[2] Each time a barge is repositioned, the shipper must report the movement to the Corps in Vessel Operation Reports.

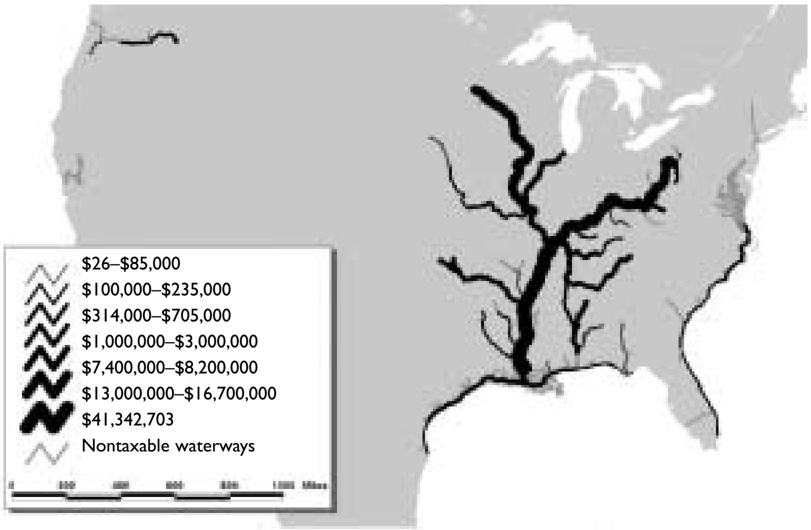


FIGURE 1 Fuel tax waterways by 1999 revenue.

average delay at the lock, average processing time, tow size, and empty return rate;

- Shallow-draft vessel costs; and
- The Mid-America Study, which provides the upbound and downbound towboat speeds for each river.

The WCSC loaded file, when combined with the river miles from dock to dock, allows an estimate of ton-miles by trip. Other data are merged to estimate fuel consumption by trip segment.

Only recently did the Corps begin to use link codes for route data throughout the inland river system. Without the link codes data, the development of the REM probably would not have been possible. Each link within a route is extracted from the WCSC loaded file, and the mileage is determined—or computed if it is a first or last link. If the movement traverses a lock within a link, the record includes a processing and delay time based on monthly averages.

At this point, the REM has assembled the total miles and processing or delay times for each link within all movements. The REM also contains estimated upbound speeds, downbound speeds, and average horsepower for each waterway. Average horsepower by link is used whenever the horsepower is not available from the vessel file. The upbound speed and downbound speed determine the amount of time spent within the waterway link.

From these computations, the REM determines actual running, processing, and delay times for each link. The REM employs an algorithm, developed from the Fiscal Year (FY) 1997 and FY 2000 Planning Guidance Shallow-Draft Vessel Costs, to assign fuel consumption for running, processing, and delays within individual waterways. All of the individual computations within the links are added together to determine the total fuel consumption in gallons by waterway.

Fuel Taxes

The establishment of the Inland Waterway Trust Fund identified a 10,700-mile network of navigable river systems subject to fuel taxes (Figure 1). The network represents about 58 percent of the total inland river system, which comprises approximately 18,300 miles.

The Trust Fund legislation also established a tax—currently 24.4 cents per gallon—on diesel fuel for the portion of any movement on the fuel-tax network in nonoceangoing vessels—vessels that do not draft more than 12 feet.[3] Towing operators pay the tax to the U.S. Treasury, which maintains records only for the national system—the Treasury does not maintain regional data. Of that tax, 4.3 cents per gallon does not go to the Trust Fund but is marked for debt reduction. Therefore the REM uses the tax rate of 20.1 cents per gallon to convert fuel consumption by waterway into fuel tax receipts by river.

This conversion accomplishes two purposes. First, fuel tax estimates by river were not available before TVA developed the REM, and policy makers—especially in Midwestern states—maintained adamantly that the data were necessary for river system policy development. TVA has provided these data to the Trust Fund User Board members, the Midwest Area River Coalition, and the Iowa State DOT.

Second, the REM fuel tax estimates can be checked against the national fuel tax collection data. TVA assumes that if the REM efficiency ratings translate to a fuel tax amount close to the total tax receipts published by the Treasury, then the estimates of river efficiency are reliable.

Table 1 relates the REM calendar-year estimates of national fuel tax collections to data published by the Treasury for 1993 through 1999. For 1996 through 1999, the average absolute annual difference between estimates made by the REM and the data reported by

TABLE 1 Fuel Taxes and Estimates, 1993–1999

Year	Treasury Data	REM Estimate	Difference
1993	$ 82,975,700	$ 69,491,764	–16.3%
1994	91,039,600	80,774,426	–11.3%
1995	106,172,030	100,980,228	–4.9%
1996	100,982,400	100,977,143	0.0%
1997	100,293,948	100,141,573	–0.2%
1998	97,159,316	99,219,614	2.1%
1999	106,082,016	106,901,160	0.8%

[3] On the Columbia–Snake River, the local district considers certain barges—classified as oceangoing elsewhere—to be providing inland service at depths up to 14 feet. The REM classes these as inland barges and includes the towing companies as paying taxes into the Inland Waterway Trust Fund.

TABLE 2 Ton-Miles and Fuel Tax Estimates for Selected Waterways, 1999

Waterway	Miles (millions)	Ton-miles (millions)	Gallons (millions)	Ton-miles per gallon	Fuel Tax
Black Warrior and Tombigbee Rivers, Ala.	3.024	4,637.661	9.891	468.9	$1,988,153
Kanawha River, W.V.	1.032	1,451.344	5.514	263.2	1,108,313
Tennessee River, Tenn., Ala., and Ky.	4.864	7,692.819	14.430	533.1	2,900,403
Ohio River	36.202	57,840.376	83.085	696.2	16,700,138
Mississippi River, mouth of Ohio River to Baton Rouge, La.	77.951	126,216.97	205.685	613.6	41,342,703
Mississippi River, mouth of Missouri River to Mouth of Ohio River	12.853	20,825.903	40.761	510.9	8,192,907
Mississippi River, Minneapolis, Minn., to mouth of Missouri River	11.421	17,831.293	64.649	275.8	12,994,457
McClellan-Kerr, Ark., River Navigation System	1.668	2,459.668	5.768	426.4	1,159,328
GIWW, Mississippi River, La., to Sabine River, Texas	4.661	8,342.379	13.858	602.0	2,785,541
IWW, Sabine River to Galveston, Texas	1.535	3,747.436	5.021	746.3	1,009,265
GIWW, Galveston to Corpus Christi, Texas	1.507	3,452.724	5.657	610.4	1,136,962
Cumberland River, mouth, to Nashville, Tenn.	1.449	2,387.223	5.553	429.9	1,116,147
Illinois River (including the Illinois Waterway Consolidated)	5.338	8,454.391	36.849	229.4	7,406,709
Totals for all waterways	171.52	277,821.16	531.847	522.4	106,901,160

NOTES: A complete set of data is available from the authors. GIWW = Gulf Intracoastal Waterway; IWW = Intracoastal Waterway.

the Treasury is 0.78 percent. The difference for the earlier years is greater, because the REM calibrates some operational data to be compatible with current data.[4] Making changes to increase compatibility with earlier data would be too expensive.

Efficiency and Fuel Tax Data

River system data for 1999 are reported in Table 2 for selected rivers or segments of rivers and for all rivers. The 1999 total estimate of 522.4 tmpg approximates Eastman's value of 514 tmpg for barges (3). Several low-tonnage rivers registered high efficiencies in 1999 but have varied from year to year, depending on whether locks were traversed, as well as on other factors.

Efficiency rankings of the high-tonnage rivers may appear counterintuitive. For example, the Lower Mississippi River registers 613.6 ton-miles per gallon—17.5 percent higher than the national average. However, contrary to expectations, the efficiency of the Lower Mississippi River ranks behind the Ohio River and the Gulf Intracoastal Waterway (GIWW) for Sabine River to Galveston, Texas. The Upper Mississippi River—from Minneapolis, Minnesota, to the mouth of the Missouri River—and the Illinois River register low efficiencies of 275.8 and 229.4, respectively.

[4] For example, data on backhaul rates for rivers or segments of rivers that have no locks are programmed into the REM.

The backhaul rates and towboat horsepower data supplied to the Corps by the towing companies provide two explanations for the rankings. High backhaul rates, low current speeds due to the lock and dam network, and only minor delays at the locks are partly results of an aggressive modernization program to make the Ohio River highly efficient. In contrast, the Upper Mississippi River and Illinois Waterways are relatively inefficient because of delays at the single-chamber and undersized locks and also because of higher average horsepower per towboat.

The Lower Mississippi River is efficient because of open-river navigation and a lower average horsepower per towboat. Some of the tonnage moving on the Lower Mississippi River is being towed downstream with lower horsepower boats, which also move the empty barges north via the Tennessee Tombigbee Waterway (TennTom).

The empty return ratio on the TennTom during the last five years has averaged about 113 percent—that is, for every downbound load of covered or open-hopper barges, 1.13 empty barges return. TVA research has determined that approximately 10 percent of the towboats moving downbound with loaded barges on the Lower Mississippi River are also moving empty barges upbound on the TennTom.

Fuel tax collections concentrate on the mainstem Mississippi and Ohio Rivers. In 1999, fuel

Aerial view of navigation on the Mississippi River.

consumption on the Mississippi River generated $62.5 million, and the Ohio River generated $16.7 million. Fuel taxes collected for the Illinois River totaled $7.4 million in the same year. Total collections on the Upper Mississippi River and Illinois Waterways reached $20.4 million in 1999.

The relatively high fuel tax collections on the Upper Mississippi River and Illinois Waterway are also explainable in part by a miles-per-trip average that is almost 300 percent more than the average on the rest of the inland system. Cargo on the Upper Mississippi River and the Illinois Waterway averages 670 miles per trip, compared with 170 miles per trip on other segments of the inland river system.

Scenario Applications

The REM can discriminate among different types of barge traffic or different geographic definitions of the inland waterways system. For example, the model can apply to the entire inland river system, not only for the fuel-tax waterway portions. This allows an estimate of total fuel tax collections if the system should be expanded to the total inland system. Similarly, locks on tributary rivers can be modeled as closed to determine the impacts on the main rivers.

The model also can gauge the level of fuel taxes attributable to a river without the traffic that originates or terminates on tributary rivers. For example, for a Midwestern state DOT, TVA eliminated data for all traffic that did not originate on the Upper Mississippi River or the Illinois Waterway and applied the REM to the database.

The results showed that in 1999 the Upper Mississippi River and Illinois Waterway accounted for $52.5 million of the $106 million paid into the Trust Fund, or about 50 percent of total collections, and the Lower Mississippi River, Ohio River, and the Tennessee River accounted for, respectively, $53.7 million, $34 million, and $7.8 million. These numbers cannot be added together, because the estimates involve substantial double counting as tows pass from one river segment to another.

River Efficiency Database

Data and modeling methodologies have improved to allow comparisons of the efficiencies of rivers. Newstrand correctly pointed out that environmental review of feasibility studies concentrates on the damage that river navigation does to the stream and does not consider the benefits of barge transportation, such as decreased air pollution and increased highway safety.

TVA developed the REM software to produce a database of river efficiencies. The REM has yielded an offshoot—a database of fuel tax collections by river. The fuel tax data are valuable in developing national waterway policy and also serve to gauge the accuracy of the REM efficiency estimates.

The efficiency data rank the Ohio River as one of the most efficient rivers, closely followed by the Lower Mississippi. The Upper Mississippi River and the Illinois Waterway are relatively inefficient, partly because of 29 single-chamber and relatively small locks. The use of towboats with higher horsepower to move cargo also contributes to these inefficiencies.

Most of the fuel taxes are collected from traffic on the mainstem rivers. However, the proponents of tributary navigation point out that the tributaries are vital in feeding mainstem traffic. The REM corroborates this—according to the model, in 1999 tow traffic originating or terminating on the Upper Mississippi River and the Illinois Waterway generated nearly 50 percent of total fuel tax collections.

References

1. Newstrand, M. W. Environmental Impacts of a Modal Shift. In *Transportation Research Record 1333*. TRB, National Research Council, Washington, D.C., 1992, pp. 9–12.
2. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Water Resources Council, U. S. Department of the Interior, 1983.
3. Eastman, S. E. *Fuel Efficiencies in Freight Transportation*. June 1980.
4. Tolliver, D. *Analysis of the Energy Emissions and Safety Impacts of Alternative Improvements to the Upper Mississippi River and Illinois Waterway Systems*. U. S. Army Corps of Engineers, Rock Island District, 2000.

Bringing the Ocean to Oklahoma

Waterway Is Economic Engine for Region

ROBERT W. PORTISS

The ocean officially reached Tulsa, Oklahoma, in December 1970 when the 445-mile McClellan-Kerr Arkansas River Navigation System was completed. Beginning at the confluence of the White and Mississippi Rivers, 600 river miles north of New Orleans, the waterway extends northwest through Pine Bluff, Little Rock, and Fort Smith, Arkansas, crosses into Oklahoma, continues through Muskogee and then to the head of navigation at the Tulsa Port of Catoosa, near Tulsa.

The McClellan-Kerr, authorized by the Rivers and Harbors Act of 1946, is more than a navigation system. A multipurpose project, the system provides water, hydroelectric power, wildlife conservation, flood control, and transportation benefits to the central states region. In the process, the system generates and supports jobs.

Navigation has attracted industrial investments exceeding the $1.3 billion to build the waterway. The area between and including the Port of Muskogee and the Tulsa Port of Catoosa has gained more than $5 billion in industrial investments and 5,000 new jobs since the waterway opened.

The Tulsa Port of Catoosa is the largest port and industrial park combination on the McClellan-Kerr. More than $21 million in general obligation bonds was required to create the complex, and by the end of 2001, the total public investment had reached approximately $50 million.

Money earned by port activities, reinvested by the City of Tulsa–Rogers County Port Authority, has generated more than $226 million in private industrial investment by more than 50 businesses that have located in the industrial park. By 2001, these businesses employed approximately 3,000 workers with an annual payroll of $103 million.

Aerial view of Tulsa Port of Catoosa, an excavated "slack water port" with no inlet, filled with backwash from Verdigris River at lower right. After joining the Verdigris, vessels from port travel 50 miles to connect with Arkansas River.

Since opening, the port has handled an impressive 47 million tons of cargo—the equivalent of 78,000 semitrailer trucks. The cost of barge transportation is approximately one-third that of rail and one-fifth that of trucking—providing an enormous savings for shippers. The safe, environment-friendly mode of waterways transportation is a proven economic engine for the region.

The author is Port Director, Tulsa Port of Catoosa, Oklahoma.

Dry cargo dock bridge crane at Tulsa Port of Catoosa lowers 205-ton quarry truck—built in Tulsa—onto jumbo hopper barge for shipping to Philippines.

Barges carry dry bulk materials for fertilizer 1,000 miles via McClellan-Kerr Arkansas System from Louisiana to Tulsa Port of Catoosa, then are cleaned and loaded with hard red winter wheat for delivery to New Orleans on return trip.

Safety Statistics That Make a Difference

U.S. Coast Guard, American Waterways Operators Partner for Results

DOUGLAS W. SCHEFFLER AND DAVID H. DICKEY

Scheffler is Manager, Research and Data Analysis, The American Waterways Operators, Arlington, Virginia, and Dickey is Program Analyst, Office of Investigations and Analysis, Marine Safety and Environmental Protection, U.S. Coast Guard, Washington, D.C.

In 2001, the Safety Partnership of the U.S. Coast Guard (USCG) and The American Waterways Operators (AWO)—the national trade association for the tugboat, towboat, and barge industry—produced a report on key safety statistics, covering crew fatalities, oil spills, and vessel casualties for 1994 to 1999. The findings point the way to the shared goal of "result-oriented action" (*1*).

Through the Safety Partnership, USCG and AWO cooperate to improve marine safety and environmental protection. Sound analysis, open dialogue, and nonregulatory solutions are the hallmarks of the initiative (2).

The Safety Partnership, which began in September 1995, was the first between USCG and a marine organization under the 1994 USCG Prevention Through People (PTP) safety initiative. PTP focuses on the human element in reducing casualties, protecting the environment, and increasing efficiency and reliability (*3*).

A national Quality Steering Committee (QSC) that consists of members of USCG and AWO guides the cooperative efforts. Since 1995, more than 200 USCG and AWO member volunteers have participated on more than 20 Quality Action Teams at the national and regional levels, tackling critical safety issues, such as

Towboat safely maneuvers marine tank barge at Bolivar entrance to Houston, Texas, ship channel.

crew fatalities, tank barge spills, and safe operations in dangerous water conditions (2).

Measures and Principles

Recognizing the need for national safety statistics, USCG and AWO signed a Memorandum of Agreement in October 1999 mandating an annual safety report to the QSC (4). AWO and USCG staff then worked to identify and define the safety measures.

The partnership established two principles to guide the development of the statistics:

1. Present the statistics as rates. The use of rates adjusts or "normalizes" the data to account for year-to-year changes in the underlying industry operations. The rates would "produce frequency data that allow intermodal and interindustry comparisons" (5).
2. Use readily available data sources for both the numerator and the denominator of each measure and "use existing government data where possible" (5).

AWO and USCG presented the first set of safety statistics to QSC in July 2000. The data covered crew fatalities per 100 full-time-equivalent workers, gallons of petroleum product spilled per 1 million gallons moved, and vessel casualties per 1 million trip miles (5). QSC decided to proceed with a formal report, and AWO and USCG analysts undertook an in-depth review of the data.

In the interim, another year of data became available, extending the data set to 1999. These updated series and a draft report detailing the data sources and analysis methodologies were presented to QSC in July 2001, and the final report was distributed in August (4).

Safety Statistics, 1994–1999

The 2001 safety statistics report, presenting the safety statistics for 1994–1999, identified the data sources, described the methodology for constructing the time series, and included analyses of the data.

Crew Fatalities

The 2000 study defined the statistic for crew fatalities as number of deaths per 100 workers, following the standard applied by the Occupational Safety and Health Administration (5). According to the 2001 report, the numerator data are from USCG's Marine Safety Information System database and represent work-related deaths—deaths from natural causes are excluded—and missing persons. The denominator data derive from Mercer Management Consulting's Towing Industry Regional Employment Model, which estimates the total number of vessel crew employees.

The report noted that the industry's 24-hour, 7-day workweek required a conversion of the vessel crew estimate into the number of full-time-equivalent (FTE) workers on a 40-hour, 50-week work schedule. This conversion to FTEs has enabled comparisons with data from other industries (4). Table 1 shows the time series for the component data and the normalized statistic of crew fatalities per 100 workers.

TABLE 1 Crew Fatalities, 1994–1999

	1994	1995	1996	1997	1998	1999
Deaths	27	24	31	32	24	25
Missing	1	1	3	4	4	3
Total fatalities	28	25	34	36	28	28
Estimated number of workers (FTEs)	91,284	81,994	82,793	83,020	84,009	82,314
Deaths per 100 workers	0.03	0.03	0.04	0.04	0.03	0.03

FTE = full-time employee.

The time series show a consistent range of 0.03 to 0.04 fatalities per 100 workers per year—about 30 ± 6 fatalities per year. The raw counts and the "normalized" series both indicate an essentially flat pattern through the study period.

The number of fatalities in the study period, 179, was "sufficiently small enough to lend itself to a 100 percent study," the report noted. An analysis of all the accident reports was proposed to detect any patterns: "Multiple fatality accidents should receive special attention. Possible factors of interest include work experience, time of day, number of days on duty, and amount of training" (4).

The QSC accepted the suggestion for an in-depth study of the fatal incidents. Preliminary results were presented in January 2002 and are summarized later in this article.

Oil Spills

The oil pollution safety statistic is the number of gallons of oil spilled by tank barges per 1 million gallons moved. The numerator data—total gallons spilled—derive from USCG's Polluting Incident Compendium, and the denominator data derive from the U.S. Army Corps of Engineers annual publication, *Waterborne Commerce of the United States* (4). Table 2 displays the number of gallons spilled, the number of gallons

TABLE 2 Oil Spills, 1994–1999

	1994	1995	1996	1997	1998	1999
Gallons spilled	1,021,523	1,223,066	1,245,393	193,815	272,761	228,951
Millions of gallons moved	68,541	67,490	68,637	71,518	70,153	67,981
Gallons spilled per million moved	13.9	16.3	16.9	2.3	3.5	2.3

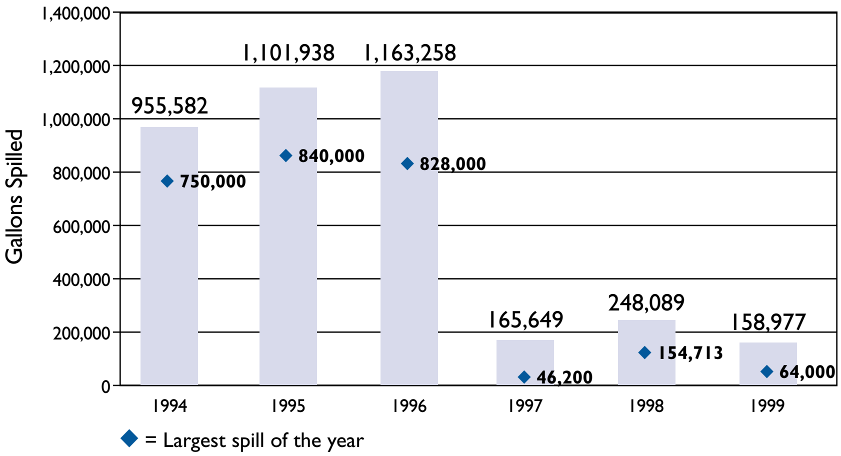


FIGURE 1 Tank barge spill volumes and volume of largest spill each year, 1994–1999.

moved, and the spillage per 1 million gallons moved for 1994–1999.

The next step was to examine tank barge spills. The data showed that every year one major accident accounted for the majority of tank barge spills. Figure 1 shows the gallons spilled in each year and the single largest incident. The data do not indicate a trend, and specific causes of the recent decrease in spills are uncertain.

The report, however, points out several factors that may have contributed to the decline in spill volumes, such as implementation of the Oil Pollution Act of 1990 and of the Responsible Carrier Program. Nonetheless, it was noted that "three years is not long enough to statistically identify a trend, so a certain amount of randomness may be involved." This raised the question, "If operational or technical factors account for most of the favorable results in recent years, are they permanent or will the industry operators and regulators become complacent, leading to a resurgence in spills?"

The incident reports indicate that most major spills were caused by groundings and collisions. The vessel casualty statistics, however, show that towing groundings, collisions, and allisions remained essentially unchanged during the study period. Possible reasons for the decrease in spills are that improved operational practices and an increased number of double-hulled vessels have reduced the severity of incidents. With the focus on crew fatalities, no follow-up studies have investigated the dramatic reduction in oil spills.

TABLE 3 Vessel Casualties, 1994–1999

	1994	1995	1996	1997	1998	1999
Number of vessel casualties	2,986	3,641	3,764	3,407	3,405	2,939
Millions of trip miles	48.443	52.244	51.423	51.263	52.430	52.137
Vessel casualties per 1 million trip miles	61	70	72	66	63	56

TABLE 4 Tugboat and Towboat Casualties per 1 Million Trip Miles, 1994–1999

	1994	1995	1996	1997	1998	1999
Grounding	26	31	28	24	22	19
Allision	15	18	20	19	17	14
Loss of vessel control	5	8	9	9	10	10
Collision	8	6	7	7	6	6
Equipment failure	1	1	2	1	2	2
Breakaway	2	1	1	1	1	1
Sinking	1	1	1	1	1	1
Flooding	1	1	1	1	1	1
Loss of electrical power	0	1	1	1	1	1
Fire	1	1	1	1	1	1
Structural failure	1	1	1	1	1	0
Capsize	0	0	0	0	0	0
Explosion	0	0	0	0	0	0

Vessel Casualties

The term "vessel casualties" refers to all types of losses or damages to a towboat, tugboat, or barge. USCG classifies casualties as allisions, breakaways, capsizings, collisions, equipment failures, explosions, fires, floodings, groundings, losses of electrical power, losses of vessel control, sinkings, and structural failures. The safety measure for vessel casualties is the number of incidents per 1 million miles traveled.

The numerator data are extracted from USCG's Marine Safety Management System and represent the total number of vessels involved in accidents. For example, if a towboat pushing five barges collides with another towboat pushing three barges, 10 vessels are listed as involved in the casualty. The primary cause of the accident determines the casualty type.

The denominator data—trip miles—are supplied by the Corps' Navigation Data Center (NDC) in New Orleans, Louisiana. The data are not published but are generated through a customized query of the NDC databases and represent distances traveled by American towboats on navigable waters of the United States (*4*). Table 3 shows the number of vessel casualties, the number of trip miles, and the normalized vessel casualty time series.

To investigate the fluctuations in the normalized series, the data were analyzed by vessel type. The data show that towboat and tugboat casualties accounted for 56.3 percent of the total casualties in the study period. Across the years the percentage ranges from 50.5 percent to 61.0 percent. The casualty data were normalized assuming one power unit—towboat or tugboat—per trip (*4*). Table 4 presents the towboat and tugboat casualties per 1 million trip miles.

The report identified three major concerns about the data:

◆ The 1994 data are significantly lower than the 1995–1999 data, yet there are no reporting, database, or programming explanations. Because 1994 was the year after a flood had damaged the navigation system, the intuitive expectation would be for higher casualty rates. If 1994 is taken as representative of preceding years, then the 1995–1999 period shows a level shift—or "quantum leap"—in casualty rates.

◆ Inconsistency emerges across the series. Groundings and allisions show downward trends from respective peaks in 1995 and 1996, but loss of vessel control and—to a lesser extent—loss of electrical power show steady increases. This cautions against general statements about trends in the aggregate data.

◆ The magnitude of the changes in the individual casualty series for the 1995–1999 period reveals volatility and inconsistency. The absolute percentage change for groundings, allisions, loss of vessel control, and collisions is 11.6 percent. (The data sets for other casualty types are so small that any change would generate large percentages.)

The volatility of the individual casualty data suggests that the casualty rate for towboats and tugboats for the 1994–1999 period may be viewed as a "trading range," to use a Wall Street term for normally expected fluctuations. Casualties range from about 34 to 41 per 1 million trip miles, or an average of about 37 casualties per 1 million trip miles, plus or minus about 10 percent. Since towboat and tugboat casualties comprise 50 to 60 percent of all cases, the vessel type explains a significant amount of the variability in the aggregate series.

The aggregate series show a steady decline from 72 casualties per 1 million trip miles in 1996 to 56 in 1999. However, the analyses have found that the individual vessel casualty data series are marked by inconsistency and volatility. The data do not have sufficient duration or detail to determine the variation to be expected within the series.

The observed changes could result from operational changes, such as improved training and enforcement programs, or from normal volatility, or both. The variability and inconsistency in the casualty-type data, the shortness of the time series, and the limited scope of the study prevent a determination of the relative strengths of the causes. Because of the uncertainty within the data, the downturn in the aggregate series cannot be characterized as the start of a trend.

To obtain more information, a detailed examination of the top four casualty types was proposed. A random sample, sufficient to provide meaningful data, will be studied for groundings, collisions, allisions, and loss of vessel control.

Ensuring safety and preventing spillage on waterway, petroleum service tankermen check barge wing tanks before making transfer (*right*). Liquid cargo is carefully controlled and monitored (*left*).

The reports of each sampled incident and data from other sources will be examined to detect any patterns. Geography and localized weather incidents, such as droughts and floods, will be considered. The relatively stable collisions series can serve as a point of comparison and may provide insights into the volatility of the data even before the data gathered in the out-years can confirm or negate the apparent trend in the aggregate series.

Building on the Report

The QSC met in January 2002 to receive progress reports and to conduct strategic planning (*6*). Progress reports included the crew fatality analysis, updates on the numerator data for the safety statistics, and the strategic planning results.

Crew Fatality Analysis

As directed by the QSC in July 2001, USCG staff analyzed the fatality data. Capt. Mike Karr, Chief of the Investigations and Analysis Division, presented a preliminary report on the findings. Data indicated that falls overboard continue to be a major cause of crew fatalities.

USCG records of towing industry fatalities count crew member fatalities as well as fatalities involving towing vessels (e.g., recreational boaters killed in an accident involving a towing vessel). The report, however, included only crew member fatalities. The QSC has asked for an examination of both types of

TABLE 5 Safety Incidents, 1994–2000

	1994	1995	1996	1997	1998	1999	2000
No. of crew fatalities	28	25	34	36	28	28	12
Gallons of oil spilled	955,582	1,101,938	1,163,258	165,649	248,089	158,977	133,540
No. of vessel casualties	2,986	3,364	3,764	3,407	3,405	2,939	2,686

fatalities to identify any trends or necessary safety improvements (*6*).

Numerator Data Updates

USCG staff also produced Calendar Year 2000 frequency or numerator data for the next edition of the safety statistics report (Table 5). The Corps data that are used as the denominator for the normalized safety statistics, however, were not available until May 2002.

The USCG data show decreases in all three numerator series, but according to the report, "analysis of the normalized series is needed to show the changes in the context of industry activity" (*6*). Now that the Corps data have become available, the safety statistics report will be updated and presented to the QSC.

Strategic Planning

The strategic planning session sought to "lay the foundation for the future work of the partnership" (*6*). The QSC identified four goals:

1. Promote and maintain a downward trend in crew fatalities, oil spills, and vessel casualties involving tugboats, towboats, and barges;
2. Improve measurements to target the partnership's efforts and to assess results;
3. Review the partnership's structure and work processes, including the relationships between the national and regional QSCs and between the partnership and the AWO Safety Committee, and make refinements as necessary; and
4. Improve communications to and from the partnership.[1]

To achieve these goals, the QSC outlined a series of steps that include:

1. Normalizing the 2000–2001 safety statistics data and identifying trends;
2. Establishing a statistics working group to assist the data analysis team by providing an operational perspective;
3. Convening the USCG and AWO cochairs of the national and regional QSCs to assess the structure of the partnership; and
4. Establishing an ad hoc group to look at the partnership's communications process and propose improvements (*6*).

USCG and AWO staff are working on these assignments. The QSC will meet again this summer or fall. The AWO website, www.americanwaterways.com, will post updates.

Safety Through Teamwork

In 2001, Rear Admiral Paul Pluta, the Coast Guard's Assistant Commandant for Marine Safety and Environmental Protection, summarized the PTP's success:

> Beginning [with] the first formal partnership… between the Coast Guard and the American Waterways Operators, the Coast Guard has enjoyed great success with each of its nine Prevention Through People (PTP) partnerships, [which] follow a nonregulatory approach to addressing safety and environmental protection.…The greatest reason for these partnerships' success is [that]… each partnership is founded on teamwork and a firm commitment to achieving the highest possible level of safety for each member of the maritime community. (*7*)

The safety statistics program is a valuable initiative of the USCG–AWO Safety Partnership. Based on agreed-to sources and methods, the safety statistics allow the QSC to measure safety performance over time, benefiting USCG, AWO, and the towing industry.

References

1. Brandt, A., and J. Kelly. American Waterways Operators/PTP Partnership. In *Proceedings*, Marine Safety and Environmental Protection Directorate, U.S. Coast Guard, July–September 2001, p. 6.
2. U.S. Coast Guard. www.uscg.mil/hq/g-m/nmc/ptp/ptppart/awo.htm, 2000.
3. U.S. Coast Guard. www.uscg.mil/hq/g-m/nmc/ptp/ aboutptp.htm, 1999.
4. Dickey, D. H., and D. W. Scheffler. U.S. Coast Guard–AWO Safety Statistics Collaboration: Trends in Crew Fatalities, Pollution, and Vessel Casualties. Unpublished report, American Waterways Operators, July 19, 2001.
5. Hill, L. H. USCG Marine Safety Data Workshop. American Waterways Operators, July 2000.
6. *AWO Letter*. Feb. 8, 2002, p. 8.
7. Pluta, P. Assistant Commandant's Perspective. In *Proceedings*, Marine Safety and Environmental Protection Directorate, U.S. Coast Guard, July–September 2001, p. 2.

[1] Carpenter, J. K., private communication to AWO and USCG staff, March 1, 2002.

Barge Impacts on Bridges

Collision Test in Florida Will Affect Bridge Design Specifications

GARY CONSOLAZIO, RONALD A. COOK, HENRY T. BOLLMANN, AND J. DARRYLL DOCKSTADER

The design and evaluation of bridges that cross navigable waterways must consider the effect of impacts by ships or barges. The Arkansas River barge crash that collapsed a 600-foot section of an Interstate 40 bridge and killed 14 people near Webbers Falls, Oklahoma, in May has given new urgency to related bridge design guidelines.

Bridge design documents—such as the American Association of State Highway and Transportation Officials' (AASHTO) *Guide Specification and Commentary for Vessel Collision Design of Highway Bridges*—address potential vessel impacts through code-based loading conditions. Few tests have produced data from actual impacts.

The replacement of the SR 300–Saint George Island Causeway bridge near Apalachicola, Florida, with a new bridge now under construction has provided the Florida Department of Transportation (DOT) an opportunity to measure barge impact forces directly. After the new bridge opens to traffic in 2003, Florida DOT will test-crash a hopper barge at various speeds into the older structure, to obtain direct measurements of the lateral forces imparted to the bridge piers.

Because a large number of bridges in the state cross navigable waterways, Florida DOT has sought reliable and accurate barge impact-load data for use in bridge design, retrofit, and evaluation. The department would like to ensure that the lateral impact loads used for design are effective but do not result in unnecessarily expensive bridge designs.

Feasibility Study

The first phase of the project determined the feasibility of the full-scale test on the bridge and established the test parameters. Researchers investigated environmental, geographical, and scheduling issues. The scope of work for this phase included several tasks:

- Review the AASHTO barge-impact provisions.
- Search the literature for barge-impact testing programs.
- Outline ways to maximize the usefulness of the data collected, as well as the probability of success in obtaining permits, in scheduling the test, and in managing project costs.
- Review the environmental permitting issues—including regulations about oyster beds, manatees, bird sanctuaries, noise restrictions, and water turbidity—as well as the environmental permitting documents filed by the new bridge's contractor.
- Select the most appropriate type and size of barge, obtain cost estimates, and determine the tug requirements to navigate the barge for the impact test.
- Review water depth data, conduct an onsite bathymetric survey, and determine the most appropriate barge acceleration paths, considering the new bridge and features such as oyster beds and power lines.

Before demolition in 2003, St. George causeway bridge near Apalachicola, Florida, will absorb series of barge test-crashes, to generate new data for bridge design.

- Develop a schedule for the test and ensure that the test will not conflict with the requirements of the contractor removing the old structure.
- Develop finite element models for a hopper barge and selected piers—including soil data—in the old bridge and conduct simulated impact scenarios.
- Determine the barge size and cargo mass that will maximize the variety of impact tests that can be conducted safely on the old St. George Island bridge.
- Use the finite element model results to design and develop instrumentation systems for measuring the impact loads.

Preparing for the Test

The first phase demonstrated the feasibility of the impact testing program and established the time window for the full-scale testing, the testing location, the barge acceleration path, and the preliminary test conditions. Florida DOT is now proceeding to the physical test phase, set for summer 2003.

The test is expected to yield information that will influence bridge design codes worldwide. Codes—and computer models—may be modified to produce vessel collision force results that predict actual impact forces more accurately.

The research results also will assist engineers in other disciplines. For example, geotechnical engineers will gain information about the stiffening effect of pore water when soil is rapidly loaded. Bridge designers will learn more about achieving the correct distribution of loads to an impacted pier and predicting the loads shed, or distributed, to the superstructure and shared with the adjacent piers.

Consolazio and Cook, principal investigators for the study, are on the civil engineering faculty of the University of Florida, Gainesville. Bollmann is Senior Bridge Designer and Dockstader is Technology Transfer Manager, Florida Department of Transportation, Tallahassee.

Integrating Inland Waterways into Intermodal Systems

Initiatives Promote Technologies, Cooperative Efforts

JAMES R. McCARVILLE

With freight traffic doubling every 20 years, ports and carriers are adapting the inland waterways transportation system (IWTS) to the requirements of intermodal shipping. IWTS offers the cleanest, safest, and cheapest means of moving large quantities of bulk materials to and from inland ports. The social, environmental, and safety pressures of congestion present opportunities for IWTS to contribute to reducing road and rail congestion, greenhouse gas emissions, and traffic fatalities, as well as the cost of doing business.

To integrate IWTS into an intermodal system, all components must work in concert to effect changes in transportation technologies, intermodal business practices, and interinstitutional organizational models. Much of this cooperative activity is already under way.

Port of Pittsburgh's SmartBarge webpage (www.SmartBarge.com) offers shippers tools to compare prices among barge, truck, and rail transportation; request shipment prices; and check barge availability.

The Maritime Transportation System National Advisory Council has called for two new study teams to present the cases for coastal barging and inland waterways. In addition, under the sponsorship of the Maritime Administration, an informal study group of port, carrier, and government representatives has been meeting to define the necessary steps to integrate IWTS into an intermodal system in the next 5 to 10 years. Possible initiatives include

- A central clearinghouse or knowledge base for IWTS;
- Practical business planning to implement container-on-barge (COB) business;
- Marketing data research and education outreach to third-party logistics companies, state and local planning organizations, and intermodal partners; and
- Integration into the Marine Transportation System (MTS) through the new MTS Inland Waterway Team.

With grants from the U.S. Department of Transportation and the Maritime Administration, the Port of Pittsburgh Commission has organized an industrywide technology advisory committee, which has identified opportunities for advanced navigation projects, such as

- Operator-assisting sensors and technologies to navigate in fog and to enter locks;
- The integration of Global Positioning System and geographic information system data into radar systems; and
- Real-time depth information and systems to predict water levels and loading thresholds.

The committee is also looking at other industry-sponsored research into operations, safety, and environmental improvements.

With Carnegie Mellon University, the Port of Pittsburgh Commission undertook the initial project, developing a web-based marketing tool to provide new shippers with information about the costs of moving a container to or from Pittsburgh. After launching and refining the website, www.SmartBarge.com, the project partners are preparing a similar tool for use by any inland port. In a second project, the Port of Pittsburgh has asked Carnegie Mellon University to evaluate specific technologies for improving the inland system.

In other related developments, carriers are expanding rapidly into the COB market. Osprey Line, which has offered COB service between Houston, Texas, and New Orleans, Louisiana, is expanding to Baton Rouge, Lousiana, and may add services in Memphis and Brownsville, Tennessee, by the end of the year.

The Ohio and Mississippi Rivers and their navigable tributaries are transportation corridors of national importance. In the debate to reauthorize the Transportation Equity Act for the 21st Century, the inland waterways and coastal barge interests are making the case that there are easier ways to add capacity to the U.S. freight system than building highways. Although more highways must be built, the inland waterways are gaining consideration as integral, intermodal connectors—vital parts of the nation's transportation system.

The author is Executive Director, Port of Pittsburgh Commission, Pittsburgh, Pa.

Improving European Waterways Navigation

Danube Corridor Offers Key to Economic Development

REINHARD PFLIEGL

The author is with Donau Transport Entwicklungsgesellschaft, Vienna, Austria.

The inland waterways of Europe have vast, unused capacity. The European Commission and national representatives recently declared that the corridor from Amsterdam and Rotterdam, Netherlands, and Antwerp, Belgium, on the North Sea—the ARAports—to Constanza and Sulina, Romania, and Izmail, Ukraine, on the Black Sea is of strategic importance for continued economic growth as part of the European Union's (EU) expansion in the next 5 to 10 years.

Several national and international initiatives are addressing technical, operational, legal, and commercial issues with the goal of integrating inland navigation in Europe. These activities will ensure that supply chain management can integrate all modes of transportation. In this way, available waterways capacity can be used to maximize investments and improve the quality of life for all EU citizens.

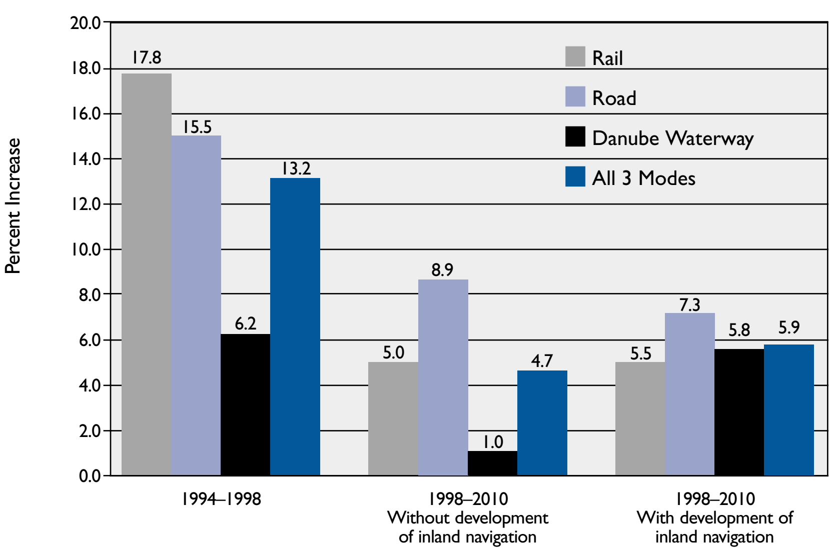


FIGURE 1 Growth and projected growth of transport volume in Danube Corridor.

The increase in traffic to the EU eastern border is expected to be more than twice the current average increase, but rail and road traffic volumes in the east-west passage of the Trans-European Network (TEN) will not be able to handle the substantial growth. Yet most of Europe's navigable inland waterways are not used heavily, and until recently, TEN strategic development had assigned a low priority to inland navigation.

The neglect of waterways may have stemmed from the traditional image of inland navigation as a slow, inflexible, unreliable, bulk-oriented, less integrable mode of transportation. Inland navigation also has lagged in incorporating new technologies, advanced logistics practices, and innovative economic concepts.

Balancing Modal Shifts

Figure 1 shows the results from a recent study of a critical section of TEN along Austria's border with Hungary, Slovakia, Slovenia, and the Czech Republic. The increase in transport volume in this sector is expected to be more than twice the average increase in Europe (7 to 10 percent per year versus 2.8 to 3.5 percent per year). The first bar chart for 1998–2010 in the middle of Figure 1 represents a scenario of economic growth without concerted activities to promote and integrate inland navigation, and the second bar chart for 1998–2010 represents a scenario of economic growth with successful implementation of new concepts to attract inland navigation.

EU wants to ensure that the available transportation infrastructure efficiently achieves a balanced modal split, as shown in the second scenario. Except for the Rhine River, which carries up to 80 percent of available capacity, Europe's inland waterways have unused capacities of 50 to 90 percent of their theoretical limits. The Danube River, for example, carries 15 percent

FIGURE 2 Waterway from North Sea (Atlantic Ocean) to Black Sea, 3800 kilometers long. (SOURCE: Oesterreichisches Institut fuer Raumplanung.)

of capacity on average, but only 10 percent of capacity in Eastern European countries.

As the Central Eastern European countries are integrated into EU, transport volumes in the next 10 years are expected to grow rapidly. Transport modes will become a key policy issue. Already the pattern of transportation flows has changed and is hampered by quantitative and qualitative bottlenecks. Efforts at improvements through investment are hindered by low national budgets and—until recently—a low priority in EU traffic policy.

Danube Waterway

The hydrographic area of the Danube River encompasses a land mass of more than 800 000 km^2. About 155 million people—approximately 27 percent of the total European population[1]—live in the Danube's riparian regions from Bavaria, Germany, to the Black Sea. The number of people with direct or indirect access to the Danube waterway—the Rhine-Main-Danube area—is approximately 320 million, nearly 57 percent of the total European population. Since economic development in the eastern parts of the Danube region lags behind the European core regions, the map in Figure 2 illustrates the economic importance of the transportation infrastructure.

For centuries, the Danube waterway was the most important transportation system in the region, contributing significantly to economic development. But in the last 150 years inland waterway transportation on the Danube has not kept pace with the dynamic development of rail and road transportation, for technological and political reasons. Public owners dominate the inland waterways, slowing competition and investment.

The opening of the Main-Danube channel in 1992 created a new trans-European waterway linking Amsterdam-Rotterdam-Antwerp and the Black Sea ports. The channel has attracted significant transport flow, but development has been modest. The recent war in Yugoslavia severely affected inland navigation, cutting off Romania, Bulgaria, and Ukraine from European markets previously reached through inland waterways. In addition, the Danube waterway has limitations in terms of year-round reliability for navigation because of shifting seasonal water levels.

Studies and Forecasts

Although inland navigation on the Danube has proved successful in low-cost, bulk cargo markets, it has failed to capture high-value cargoes. Container transport comprises less than 1 percent of total cargo on the Danube, in contrast with 10 percent of the total on the Rhine system, but several feasibility studies confirm the potential for container shipping on the Danube.

Further integration of the Central and Eastern European countries will increase west-east traffic flows in the Danube Corridor. For example, forecasts are that international transport volume in the Austrian section of the Danube Corridor will increase from 39 million tons to 83 million tons within the next 15 years on all modes.[2]

Since the overwhelming portion of this growth consists of medium- and high-value commodities, inland navigation will have to strive to retain market shares. To respond to the increasing demand, Danube navigation will need to develop effective solutions, probably involving container transport and the transport of stackable swap bodies.[3]

The upgrading of rail and road systems in the Danube Corridor of Austria has begun, with funding secured into the next decade. The situation in the Central and Eastern European countries is not as positive—financial resources have not kept pace with traffic demand.[4] New construction and upgrades of the infrastructure have proved costly and time consuming because of the legal processes associated with the requirements for ecological sustainability.

Transportation forecasts and the increase in international transportation flows over already high

[1] Figures for 1995, including Ukraine, but not the Russian Federation.

[2] Evaluation of the Danube Waterway as a Key European Transport Resource, research and development project in the 4th Framework program of the EU.

[3] Interchangeable containers for intermodal shipping.

[4] Transport Infrastructure Needs Assessment (TINA), a European project to assess transportation infrastructure.

volumes of regional traffic—especially in Austria and Hungary—indicate that the infrastructure for land-based modes will not match up with the volumes expected in the next 10 to 15 years. Parts of the Danube Corridor may become bottlenecks within the European infrastructure, like the bottlenecks in the Alpine Corridors (the north-south link in the network).

But even at bottlenecks such as Vilshofen-Straubing in Bavaria, Germany, waterway capacity use does not exceed 50 percent,[5] and the rate downstream falls well below 15 percent. The transportation capacity of the Danube waterway therefore must be exploited.

Policy Considerations

EU transport policy regards inland navigation as a low-cost, environmentally friendly, and energy-saving mode that could absorb increasing traffic flows and contribute to the European market. The TEN Outline Plan for Inland Waterways[6] highlights the importance of the Danube. The advantages of inland navigation in reducing environmental damage are also clearly stated in the 1999 Green Paper on the Impact of Transport on Environment: A Community Strategy for Sustainable Mobility, which endorsed European Commission plans to increase the market share of inland waterways.

Goods from overseas, as well as from EU member countries, are delivered to European seaports for transport to destinations within Europe. The link from the ARA ports to Central Europe is a key lifeline that can be supported by inland navigation (Figure 2). Sustainable and ecologically friendly, waterways transportation offers a short-term solution for congested road infrastructure and provides efficient transport opportunities for Central and Southeastern Europe.

Key Questions

Reliability and Accessibility

Inland waterways transportation on the Danube is considered unreliable because of traffic limitations based on water levels. However, analyses have shown that water-level changes should not be a hindrance. Multiyear averages indicate that the Rhine-Main-Danube waterway is unreliable for only 1 percent of each year due to high water—that is, the waterway is impassable 3.5 days per year, although high-water phases of more than 2 days are rare. Moreover, statistics show the same level of unreliability for railways and motorways parallel to the Danube.

[5] Shifting Cargo to Inland Waterways. European Community 5th Framework Program for Research, Technological Development, and Demonstration Activities, 1998–2002.

[6] Trans-European Network Outline Plan for Inland Waterways. Strategy Paper of the European Commission, 1999.

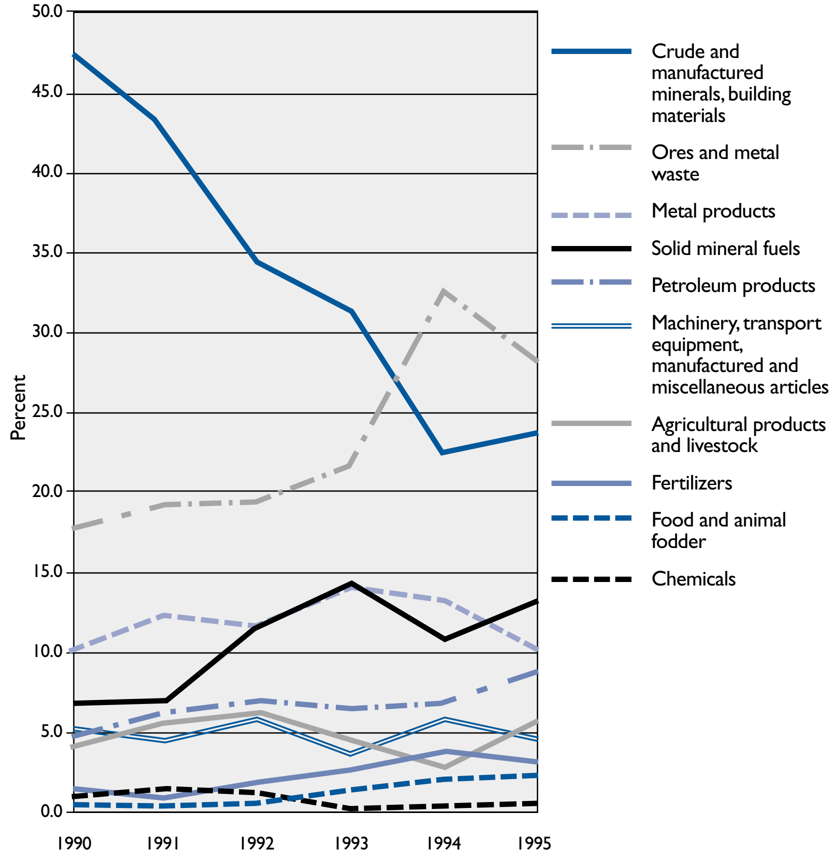


FIGURE 3 Products transported on the Danube. (SOURCE: Danube Commission.)

Quality of Service

Goods transportation on the Danube is usually associated with bulk material and low-quality feed (Figure 3). Shippers do not consider the waterway for container transportation or for deploying modern supply-chain management practices. Many have found the provision for high-quality goods movement inadequate. Moreover, compared with deep-sea vessel ports, inland waterway transport lacks the innovative services and approaches that enable partnerships and services in supply chain management structures—especially in terms of new transport opportunities, cargo handling, link ability, and information networking.

Most of the information flow between vessels and logistics providers is by voice, not by electronic transmission. Modernization will improve the quality of the service.

Addressing the Issues

What are the steps necessary to exploit waterway navigation as an innovative, reliable, and cost-effective mode for medium and long distances? First, work must be carried out to develop the strategic advantages of inland navigation—such as loading capacity, security, relatively low infrastructure costs, and a positive ecological ratio—into successful market operations.

The expansion of EU and the envisioned liberalizing of trade and lowering of tariff barriers in Southeastern Europe under the Stability Pact will generate an increase in transport volume, especially along the Danube Corridor. To satisfy the transportation needs of developing economies, an efficient infrastructure must be available within the corridor. Moreover, the Danube countries must acknowledge the importance of the corridor by signing a memorandum of understanding for development of the transportation networks.

In 2001, the European Commission proposed a revision of the TEN guidelines, giving priority to the development of inland waterways, intermodal transport, and the corresponding connections. Intermodal transport on the Danube is one of the priorities, reflecting an emphasis on shifts to more environmentally friendly modes of transportation. A shift to intermodal logistics chains with inland shipping as the main haulage will occur only if the system achieves reliability, transparency, and efficiency.

In the Danube Corridor countries, inland navigation cannot be integrated efficiently into multimodal supply chains because of several major problems:

- Loss of transport time because of border control procedures along the route;
- No reliable information about the position of inland vessels and of dangerous cargoes; and
- Lack of information about a vessel's time of arrival at an inland port, which can cause loss of time in transshipments.

River Information Services

All nations along the Danube and the Rhine have acknowledged the importance of river information services (RIS) and plan to establish a pan-European RIS by 2005. RISs contribute to safer and more efficient inland waterways transport. EU, the United Nations Economic Commission for Europe, and the Rhine and Danube river commissions will draw up the standards.[7] Two initiatives are necessary: first, preparing for a pan-European RIS installation, and second, coordinating and harmonizing the installation and operation of RISs in every country.

Pan-European RIS

In the past five years, EU has worked on the technological foundations of an RIS. Several projects have investigated the governmental aspects of administration and operations. These projects led to the preliminary standardization of the Inland Automatic Information System and the Inland Electronic Chart Display and Information System.

The Joint Research Programs[8] of the European Union have pursued technology projects specifically to improve vessel traffic management systems on inland waterways. The Inland Navigation Demonstration for River Information Services (INDRIS) developed and proved the basic concept of the RIS in several demonstration scenarios.

The success of INDRIS led to a follow-up project, Consortium for the Operational Management Platform for River Information Services (COMPRIS), under EU's 5th Framework Program for Research, Technological Development, and Demonstration. The COMPRIS project is the most significant action to precede implementation of RISs across Europe. COMPRIS entails a cooperative approach involving 64 partners from 13 countries to work on the standardization and harmonization of the RIS concept, architecture, and applications.

Steps to Implementation

The goal of COMPRIS is to create a standard for RISs in all European countries. Harmonized RISs will support governmental and commercial partners, geared to the mix of services in each country. The following steps are necessary in establishing a national RIS:

- Assigning an organization to develop and implement the service;
- Making preliminary assessments of waterway conditions and of current and future waterborne traffic;
- Assessing the requirements;
- Standardizing and harmonizing for compatibility with other RISs;
- Designing applications and system specifications;
- Contracting for installation;
- Developing an electronic nautical chart for all navigable waterways;
- Linking all governmental and commercial parties in inland navigation;
- Creating a legal framework;
- Incorporating related EU directives into national laws;
- Creating links for the international exchange of traffic and transportation information; and
- Operating RISs in every country.

Telematics services are key to improving inland waterways transport in Europe and to integrating

[7] Pan-European Conference on Inland Waterway Transport, Rotterdam, September 2001.

[8] 4th Framework, 1994–1998, and 5th Framework, 1998–2002.

intermodal supply chains efficiently. An RIS will reduce risks for safety and the environment and also will increase the efficiency of intermodal transport operations by integrating electronic information from all participants in the intermodal chain.

The first operating installation will be in Vienna, Austria, this year and will extend to 350 km in 2003. A test center will be constructed between the locks of Greifenstein and Freudenau near Vienna, to verify system functions.

Container Services

Another key element is the introduction of standardized containers in logistics chains. Standardized containers are easily loaded from one transport mode to another—a roll-on, roll-off procedure. With container-liner services, transport efficiency on the inland waterways can reach high levels, not only for bulk commodities, but also for technical cargoes.

Newly developed 45-ft. containers are now in use for intercontinental traffic in Europe. Available as a box or with a curtained side, the containers consolidate 33 europalettes and offer 82 m^3 of loading capacity. The service is integrated into current logistics solutions and offers significant cost advantages.

The container-liner service now operating as a pilot project on the Danube River connects the important economic areas of Bavaria in Southern Germany, Upper Austria, and Hungary. Regular weekly service is provided to the ports of Deggendorf, Germany; Enns, Austria; and Budapest, Hungary, in both directions.

Logistics Solutions

Accurate inland waterways traffic information data—linked interactively to logistics planning and management data—will optimize resource use, provide high-quality services, and facilitate flexible reaction to changes in demand. This will benefit consignors, shipping companies, logistics service providers, and multimodal transport operators, as well as transshipment ports and national authorities.

In 2000, EU initiated a research program—Advanced Logistics Solutions for the Danube Waterway—to improve logistics chain management services with inland navigation as the main haulage. An integrated logistics system for inland waterways would create an interactive network of all parties, enabling the planning, management, handling, and monitoring of supply chains. This type of system also addresses the faster processing of transshipments, improves administrative procedures at ship locks, provides real-time information on vessel positions, and estimates future waterways shipments.

Containers stacked at inland navigation port in Europe.

A Common-Source Logistics Database acts as an information broker for all supply-chain participants. The database offers automated data processing, communications tools, web-based services, and an integrated transport management data system. Four demonstration projects are under way to evaluate the potential of information communication technology to provide transparent and innovative services that improve reliability and flexibility and meet the requirements of supply-chain management.

Resolving Issues To Move Goods

Mobility of goods is important not only for the economic growth of the European market, but also for the integration of the Central and Eastern European countries into the economies of Western Europe. Cheap, efficient, and environment-friendly transportation will support economic and social development, particularly in the more remote regions of Eastern Europe.

Several operational, organizational, and technological activities are contributing to the development of intermodal transport chains on the Danube River. The challenge is to transfer research results into a general operating concept to meet specific regional and company-oriented requirements.

Because 14 nations form an inland waterways corridor from the Atlantic Ocean to the Black Sea, legal, administrative, and commercial issues must be resolved to facilitate the movement of goods along the corridor. Commercial success depends on high performance, high quality of service, and an environment-friendly system.

POINT OF VIEW

Waterways Option Saves an Industry

Marine Links Are Good for General Motors, Good for the United States

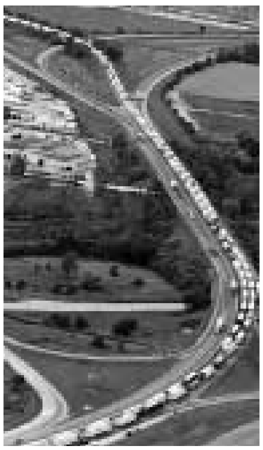
GREGG M. WARD

The author is Vice President, Detroit-Windsor Truck Ferry, Inc., Detroit, Michigan.

The aftermath of September 11, 2001, demonstrated the value of redundancy in cross-border transportation options—in particular, the merit of establishing cross-border marine links. Increased border security immediately after the attacks created a blockade to the free movement of international trade by land routes across the United States–Canada border. The fear of additional attacks on the American homeland forced border guards to scrutinize the security risk of each person and vehicle attempting entry.

Backups were more than 14 hours at the Ambassador Bridge over the Detroit River, from Detroit, Michigan, to Windsor, Ontario, and at the Blue Water Bridge over the St. Clair River, from Port Huron, Michigan, to Point Edward, Ontario. Without the arrival and departure of just-in-time shipments across the border, many industries—such as the automotive industry—can be crippled. The security blockade had a cascading effect on manufacturers in both nations—many facilities began closing down within 24 hours.

Logistics managers worked overtime to identify and implement alternative transportation plans to meet just-in-time requirements. Some found a ready solution in the waterways option.



With U.S. land border crossings nearly impassable after September 11, many just-in-time trucks shifted to a marine link between Windsor, Ontario, and Detroit, Michigan, to keep automotive plants operating.

Viable Alternative

For more than a decade, the manufacturing industry has used Detroit-Windsor Truck Ferry to transport tractor-trailers laden with hazardous materials and large, oversize or overweight loads. Beginning September 12, automotive manufacturing companies relied on the ferry to carry low-risk but critical freight across the border. The success of the Detroit-Windsor Truck Ferry alternative was instrumental in averting post-September 11 plant closings in the automotive industry.

Increased security measures at the border after September 11 produced 25-kilometer backups for U.S.-bound trucks in Windsor, Ontario, Canada.

Working cooperatively, automotive companies, suppliers, transporters, and truck ferry managers set priorities for shipments based on need. The impromptu ranking was determined by which production line would be halted or which plant would close without a shipment. That shipment then moved to the front of the line.

In a letter to the U.S. Customs Service, a spokesman for General Motors noted that after September 11, "Detroit-Windsor Truck Ferry became our only alternative that would enable General Motors to continue operation of the Detroit-Hamtramck Assembly Plant."

The economic losses from the border backups after September 11 have run into the hundreds of millions of dollars. Logistics providers have witnessed the importance of a redundant transportation network that includes all modes.

Diversifying Options

Diverse crossing options are essential—particularly at borders—if manufacturers are to continue operations during a crisis. The marine industry is a viable alternative for a portion of highway traffic. Ports and marine service providers should meet with industry to explore and develop service options.

The volume of vehicles funneled to major land-border crossing points makes the segregation of low- from high-risk freight logistically impractical. Advanced customs clearance systems become ineffective when benign shipments remain lined up behind possibly suspect or suspicious cargoes. During border emergencies, there is no way to spirit low-risk goods to the front of the line without inciting a riot among the truckers snaked for miles along the highway.

As Detroit-Windsor Truck Ferry has demonstrated, the marine industry can manage this critical task successfully. With prebooked deck space, moving vital shipments with advance reservations to the front of the line is not an issue. The round-trip cycling of vessels also allows enforcement authorities time to analyze advance data on vessel manifests and to make critical prearrival decisions.

Sustainable cross-border marine initiatives are economically feasible and advantageous to the welfare of the United States and its neighbors. The time to establish redundant transportation options is now, before another terrorist event suddenly strikes.